



Task	Specification	Specification Description
22 15 13 00	22 15 19 00	General-Service Packaged Air Compressors and Receivers



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 15 19 00 - GENERAL-SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Reciprocating air compressors - lubricated.
2. Reciprocating air compressors - oil free.
3. Reciprocating air compressors - oil less.
4. Rotary-screw air compressors - oil free.
5. Rotary-screw air compressors - oil flooded.
6. Rotary, sliding-vane air compressors - oil free.
7. Rotary, sliding-vane air compressors - oil sealed.
8. Air filters - inlet type.
9. Compressed-air aftercoolers - air cooled.
10. Compressed-air aftercoolers - water cooled.
11. Compressed-air dryers - refrigerant type.
12. Compressed-air dryers - desiccant type.
13. Computer interface cabinet.

1.2 DEFINITIONS

- A. Actual Air: Air delivered from air compressors. Flow rate is delivered compressed air measured in **acfm (actual L/s)**.
- B. Standard Air: Free air at **68 deg F (20 deg C)** and **1 atmosphere (29.92 in. Hg)** before compression or expansion and measured in **scfm (standard L/s)**.

1.3 ACTION SUBMITTALS

A. Product Data: For each product.

1. For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - b. Include operating characteristics, electrical characteristics, and furnished accessories.
 - c. **<Insert requirements>**.

B. Shop Drawings:

1. Plans, elevations, sections, and **[mounting][attachment]** details.
2. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations and size of each field connection.
3. Diagrams for power, signal, and control wiring.

C. Delegated Design Submittals: For compressed-air equipment mounting.



1. Detail fabrication and assembly of supports.
2. Include design calculations for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases, indicated to comply with performance requirements and design criteria, including analysis data[**signed and sealed by the qualified professional engineer responsible for their preparation**].

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For compressed-air equipment, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For compressed-air equipment.
1. Indicate actual installed items by marking the submittals with an arrow or box.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Air Compressor, Inlet-Air-Filter Elements: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
 2. Belts: **[One][Two]<Insert number>** for each belt-driven compressor.

1.7 FIELD CONDITIONS

- A. Interruption of Existing Compressed-Air Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service in accordance with requirements indicated:
1. Notify **[Architect][Construction Manager][Owner]** no fewer than **[two]<Insert number>** days in advance of proposed interruption of compressed-air service.
 2. Do not proceed with interruption of compressed-air service without **[Architect's][Construction Manager's][Owner's]** written permission.

1.8 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's written instructions for delivery, storage, and handling.

1.10 WARRANTY

- A. Manufacturer Warranty: **[Manufacturer agrees][Installer agrees][Manufacturer and installer agree]** to repair or replace equipment that fail in materials or workmanship within the specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Faulty operation of **<Insert components>**.
 - b. Deterioration of metals, metal finishes, and other materials beyond normal **[weathering][use]**.
 - c. **<Insert conditions relating to specified products>**.
 - d. **<Insert failure modes>**.
 - 2. Warranty Period: **[One]<Insert number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of air compressor through one source from a single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.
- C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design compressed-air equipment mounting.
- D. Seismic Performance: Compressed-air equipment to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**. **[See Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment.]**
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.3 GENERAL REQUIREMENTS FOR PACKAGED AIR COMPRESSORS AND RECEIVERS

- A. General Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled;



continuous-duty air compressors and receivers that deliver air of quality equal to intake air.

- B. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
 - 1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
 - 2. Motor Controllers: Full-voltage, combination magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
 - 3. Control Voltage: 120 V ac or less, using integral control power transformer.
 - 4. Motor Overload Protection: Overload relay in each phase.
 - 5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
 - 6. Automatic control switches to **[alternate lead-lag compressors for duplex][sequence lead-lag compressors for multiplex]** air compressors.
 - 7. Instrumentation: Include discharge-air pressure gauge, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gauges, and control transformer.
 - 8. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.
- C. Receivers: Steel tank constructed in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 1. Pressure Rating: At least as high as highest discharge pressure of connected compressors, and bearing appropriate code symbols.
 - 2. Interior Finish: Corrosion-resistant coating.
 - 3. Accessories: Include safety valve, pressure gauge, drain, and pressure-reducing valve.

2.4 RECIPROCATING AIR COMPRESSORS - LUBRICATED

- A. Reciprocating Air Compressors - Lubricated :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Atlas Copco]**
 - b. **[FS-Curtis]**
 - c. **[Gardner Denver, an Ingersoll Rand business]**
 - d. **[General Air Products, Inc]**
 - e. **[Ingersoll Rand]**
 - f. **[Kaeser Compressors, Inc]**
 - g. **[Powerex, Inc.]**
 - h. **[Quincy Compressor]**
 - i. **[Saylor-Beall Manufacturing Company]**
 - j. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Atlas Copco]**
 - b. **[FS-Curtis]**

- c. **[Gardner Denver, an Ingersoll Rand business]**
 - d. **[General Air Products, Inc]**
 - e. **[Ingersoll Rand]**
 - f. **[Kaeser Compressors, Inc]**
 - g. **[Powerex, Inc.]**
 - h. **[Quincy Compressor]**
 - i. **[Saylor-Beall Manufacturing Company]**
 - j. **<Insert manufacturer's name>**
- B. Compressor(s): Lubricated, reciprocating-piston type with lubricated compression chamber and crankcase.
1. Submerged gear-type oil pump.
 2. Oil filter.
 3. Combined high discharge-air temperature and low lubrication-oil pressure switch.
 4. Belt guard totally enclosing pulleys and belts.
- C. Receiver: ASME construction steel tank.
1. Arrangement: **[Horizontal][Vertical]**.
 2. Capacity: **<Insert gal. (L)>**.
 3. Interior Finish: **[Epoxy][Epoxy or galvanized][Galvanized]<Insert coating>** coating.
 4. Pressure Rating: **[100 psig (690 kPa)][125 psig (860 kPa)][150 psig (1035 kPa)][200 psig (1380 kPa)][250 psig (1725 kPa)]<Insert value>** minimum.
 5. Pressure Regulator Setting: **<Insert psig (kPa)>**.
 6. Pressure Relief Valve Setting: **<Insert psig (kPa)>**.
 7. Drain: **[Automatic][Manual]** valve.
- D. Capacities and Characteristics:
1. Air Compressor(s): **[One][Two][Three]<Insert number>; [single][single or two][two]** stage.
 - a. Intercooler between stages of two-stage units.
 2. Standard-Air Capacity of Each Air Compressor: **<Insert scfm (standard L/s)>** free air.
 3. Actual-Air Capacity of Each Air Compressor: **<Insert acfm (actual L/s)>** delivered.
 4. Discharge-Air Pressure: **[100 psig (690 kPa)][125 psig (860 kPa)][175 psig (1200 kPa)]<Insert value>**.
 5. Intake-Air Temperature: **<Insert deg F (deg C)>**.
 6. Discharge-Air Temperature: **<Insert deg F (deg C)>**.
 7. Mounting: **[Freestanding][Tank mounted]**.
 8. Motor (Each Air Compressor):
 - a. Horsepower: **<Insert value>**.
 - b. Speed: **[1750][3400]<Insert value>** rpm.
 9. Electrical Characteristics:
 - a. Volts: **[120][208][240]<Insert value>**.
 - b. Phase(s): **[Single][Three]**.
 - c. Hertz: **[60]<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.5 RECIPROCATING AIR COMPRESSORS - OIL FREE

A. Reciprocating Air Compressors - Oil Free: :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Gast Manufacturing Inc]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Gast Manufacturing Inc]**
 - b. **<Insert manufacturer's name>**

B. Compressor(s): Oil-free, reciprocating-piston type with nonlubricated compression chamber, lubricated crankcase, and of construction that prohibits oil from entering compression chamber.

1. Submerged gear-type oil pump.
2. Oil filter.
3. Combined high discharge-air temperature and low lubrication-oil pressure switch.
4. Belt guard totally enclosing pulleys and belts.

C. Receiver: ASME construction steel tank.

1. Arrangement: **[Horizontal][Vertical]**.
2. Capacity: **<Insert gal. (L)>**.
3. Interior Finish: **[Epoxy][Epoxy or galvanized][Galvanized]<Insert coating>** coating.
4. Pressure Rating: **[100 psig (690 kPa)][125 psig (860 kPa)][150 psig (1035 kPa)][200 psig (1380 kPa)][250 psig (1725 kPa)]<Insert value>** minimum.
5. Pressure Regulator Setting: **<Insert psig (kPa)>**.
6. Pressure Relief Valve Setting: **<Insert psig (kPa)>**.
7. Drain: **[Automatic][Manual]** valve.

D. Capacities and Characteristics:

1. Air Compressor(s): **[One][Two][Three]<Insert number>**; single stage.
2. Standard-Air Capacity of Each Air Compressor: **<Insert scfm (standard L/s)>** free air.
3. Actual-Air Capacity of Each Air Compressor: **<Insert acfm (actual L/s)>** delivered.
4. Discharge-Air Pressure: **[100 psig (690 kPa)][125 psig (860 kPa)][175 psig (1200 kPa)]<Insert value>**.
5. Intake-Air Temperature: **<Insert deg F (deg C)>**.
6. Discharge-Air Temperature: **<Insert deg F (deg C)>**.
7. Mounting: **[Freestanding][Tank mounted]**.
8. Motor (Each Air Compressor):
 - a. Horsepower: **<Insert value>**.
 - b. Speed: **[1750][3400]<Insert value>** rpm.

9. Electrical Characteristics:
- Volts: **<Insert value>**.
 - Phase(s): **[Single][Three]**.
 - Hertz: **[60]<Insert value>**.
 - Full-Load Amperes: **<Insert value>**.
 - Minimum Circuit Ampacity: **<Insert value>**.
 - Maximum Overcurrent Protection: **<Insert amperage>**.

2.6 RECIPROCATING AIR COMPRESSORS - OIL LESS

- A. Reciprocating Air Compressors - Oil Less :
- Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - [FS-Curtis]**
 - [Gast Manufacturing Inc]**
 - [General Air Products, Inc]**
 - [JUN-AIR]**
 - [Powerex, Inc.]**
 - [Squire-Cogswell/Ohio Medical]**
 - <Insert manufacturer's name>**
 - Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - [FS-Curtis]**
 - [Gast Manufacturing Inc]**
 - [General Air Products, Inc]**
 - [JUN-AIR]**
 - [Powerex, Inc.]**
 - [Squire-Cogswell/Ohio Medical]**
 - <Insert manufacturer's name>**
- B. Compressor(s): Oil-less (nonlubricated), reciprocating-piston type, with sealed oil-free bearings, that deliver air of quality equal to intake air.
- High discharge-air temperature switch.
 - Belt guard totally enclosing pulleys and belts.
- C. Receiver: ASME construction steel tank.
- Arrangement: **[Horizontal][Vertical]**.
 - Capacity: **<Insert gal. (L)>**.
 - Interior Finish: **[Epoxy][Epoxy or galvanized][Galvanized]<Insert coating>** coating.
 - Pressure Rating: **[100 psig (690 kPa)][125 psig (860 kPa)][150 psig (1035 kPa)][200 psig (1380 kPa)][250 psig (1725 kPa)]<Insert value>** minimum.
 - Pressure Regulator Setting: **<Insert psig (kPa)>**.
 - Pressure Relief Valve Setting: **<Insert psig (kPa)>**.
 - Drain: **[Automatic][Manual]** valve.

D. Capacities and Characteristics:

1. Air Compressor(s): **[One][Two][Three]<Insert number>; [single][single or two][two]** stage.
 - a. Intercooler between stages of two-stage units.
2. Standard-Air Capacity of Each Air Compressor: **<Insert scfm (standard L/s)>** free air.
3. Actual-Air Capacity of Each Air Compressor: **<Insert acfm (actual L/s)>** delivered.
4. Discharge-Air Pressure: **[100 psig (690 kPa)][125 psig (860 kPa)][175 psig (1200 kPa)]<Insert value>**.
5. Intake-Air Temperature: **<Insert deg F (deg C)>**.
6. Discharge-Air Temperature: **<Insert deg F (deg C)>**.
7. Mounting: **[Freestanding][Tank mounted]**.
8. Motor (Each Air Compressor):
 - a. Horsepower: **<Insert value>**.
 - b. Speed: **[1750][3400]<Insert value>** rpm.
9. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase(s): **[Single][Three]**.
 - c. Hertz: **[60]<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.7 ROTARY-SCREW AIR COMPRESSORS - OIL FREE

A. Rotary-Screw Air Compressors - Oil Free :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Atlas Copco]**
 - b. **[CompAir, Ltd]**
 - c. **[Gardner Denver, an Ingersoll Rand business]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Atlas Copco]**
 - b. **[CompAir, Ltd]**
 - c. **[Gardner Denver, an Ingersoll Rand business]**
 - d. **<Insert manufacturer's name>**

- B. Compressor(s): Oil-free, rotary-screw type with nonlubricated helical screws and lubricated gear box, and of construction that prohibits oil from entering compression chamber.

1. Coupling: Nonlubricated, flexible type.
2. Cooling/Lubrication System: Unit-mounted, air-cooled exchanger package prepiped to unit; with air pressure circulation system with coolant stop valve, full-flow coolant filter, and thermal bypass valve.
3. Air Filter: Dry type, with maintenance indicator and cleanable, replaceable filter element.
4. Air/Coolant Receiver and Separation System: **150 psig (1035 kPa)** rated steel tank with ASME safety valve, coolant-level gauge, multistage air-coolant separator element, minimum pressure valve, blowdown valve, discharge check valve, coolant stop valve, full-flow coolant filter, and thermal bypass valve.
5. Capacity Control: Capacity modulation between zero and 100 percent air delivery, with operating pressures between **50 and 100 psig (345 and 690 kPa)**. Include necessary control to hold constant pressure. When air demand is zero, unload compressor by using pressure switch and blowdown valve.

C. Receiver: ASME construction steel tank.

1. Arrangement: **[Horizontal][Vertical]**.
2. Capacity: **<Insert gal. (L)>**.
3. Interior Finish: **[Epoxy][Epoxy or galvanized][Galvanized]<Insert coating>** coating.
4. Pressure Rating: **[100 psig (690 kPa)][125 psig (860 kPa)][150 psig (1035 kPa)][200 psig (1380 kPa)]<Insert value>** minimum.
5. Pressure Regulator Setting: **<Insert psig (kPa)>**.
6. Pressure Relief Valve Setting: **<Insert psig (kPa)>**.
7. Drain: **[Automatic][Manual]** valve.

D. Enclosure: Steel with sound-attenuating material lining.

E. Capacities and Characteristics:

1. Air Compressor(s): **[One][Two]<Insert number>**; single stage.
2. Standard-Air Capacity of Each Air Compressor: **<Insert scfm (standard L/s)>** free air.
3. Actual-Air Capacity of Each Air Compressor: **<Insert acfm (actual L/s)>** delivered.
4. Discharge-Air Pressure: **[100 psig (690 kPa)][125 psig (860 kPa)][175 psig (1200 kPa)]<Insert value>**.
5. Intake-Air Temperature: **<Insert deg F (deg C)>**.
6. Discharge-Air Temperature: **<Insert deg F (deg C)>**.
7. Motor (Each Air Compressor):
 - a. Horsepower: **<Insert value>**.
 - b. Speed: **[1750][3400]<Insert value>** rpm.
8. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase(s): **[Single][Three]**.
 - c. Hertz: **[60]<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.8 ROTARY-SCREW AIR COMPRESSORS - OIL FLOODED

A. Rotary-Screw Air Compressors - Oil Flooded :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Atlas Copco]
- b. [CompAir, Ltd]
- c. [Gardner Denver, an Ingersoll Rand business]
- d. [Ingersoll Rand]
- e. [Kaeser Compressors, Inc]
- f. [Quincy Compressor]
- g. [Sullair Corporation]
- h. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Atlas Copco]
- b. [CompAir, Ltd]
- c. [Gardner Denver, an Ingersoll Rand business]
- d. [Ingersoll Rand]
- e. [Kaeser Compressors, Inc]
- f. [Quincy Compressor]
- g. [Sullair Corporation]
- h. <Insert manufacturer's name>

- B. Compressor(s): Oil-flooded, rotary-screw type with lubricated helical screws and lubricated gear box.

- 1. Coupling: Nonlubricated, flexible type.
- 2. Cooling/Lubrication System: Unit-mounted, air-cooled exchanger package prepiped to unit; with air pressure circulation system with coolant stop valve, full-flow coolant filter, and thermal bypass valve.
- 3. Air Filter: Dry type, with maintenance indicator and cleanable, replaceable filter element.
- 4. Air/Coolant Receiver and Separation System: **150 psig (1035 kPa)** rated steel tank with ASME safety valve, coolant-level gauge, multistage air-coolant separator element, minimum pressure valve, blowdown valve, discharge check valve, coolant stop valve, full-flow coolant filter, and thermal bypass valve.
- 5. Capacity Control: Capacity modulation between zero and 100 percent air delivery, with operating pressures between **50 and 100 psig (345 and 690 kPa)**. Include necessary control to hold constant pressure. When air demand is zero, unload compressor by using pressure switch and blowdown valve.

- C. Receiver: ASME construction steel tank.

- 1. Arrangement: [Horizontal][Vertical].
- 2. Capacity: <Insert gal. (L)>.
- 3. Interior Finish: [Epoxy][Epoxy or galvanized][Galvanized]<Insert coating> coating.
- 4. Pressure Rating: [100 psig (690 kPa)][125 psig (860 kPa)][150 psig (1035 kPa)][200 psig (1380 kPa)][250 psig (1725 kPa)]<Insert value> minimum.
- 5. Pressure Regulator Setting: <Insert psig (kPa)>.
- 6. Pressure Relief Valve Setting: <Insert psig (kPa)>.
- 7. Drain: [Automatic][Manual] valve.

- D. Enclosure: Steel with sound-attenuating material lining.

E. Capacities and Characteristics:

1. Air Compressor(s): **[One][Two]<Insert number>; [single][single or two][two]** stage.
2. Standard-Air Capacity of Each Air Compressor: **<Insert scfm (standard L/s)>** free air.
3. Actual-Air Capacity of Each Air Compressor: **<Insert acfm (actual L/s)>** delivered.
4. Discharge-Air Pressure: **[100 psig (690 kPa)][125 psig (860 kPa)][175 psig (1200 kPa)][200 psig (1380 kPa)]<Insert value>**.
5. Intake-Air Temperature: **<Insert deg F (deg C)>**.
6. Discharge-Air Temperature: **<Insert deg F (deg C)>**.
7. Motor (Each Air Compressor):
 - a. Horsepower: **<Insert value>**.
 - b. Speed: **[1750][3400]<Insert value>** rpm.
8. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase(s): **[Single][Three]**.
 - c. Hertz: **[60]<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.9 ROTARY, SLIDING-VANE AIR COMPRESSORS - OIL FREE

A. Rotary, Sliding-Vane Air Compressors - Oil Free :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Becker Pumps Corp]**
 - b. **[Gast Manufacturing Inc]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Becker Pumps Corp]**
 - b. **[Gast Manufacturing Inc]**
 - c. **<Insert manufacturer's name>**

B. Compressor(s): Oil-free, nonpulsating, rotary, sliding-vane type with nonlubricated sliding vanes.

1. Cleanable inlet screens.
2. Outlet silencers on discharge connections.

C. Receiver: ASME construction steel tank.

1. Arrangement: **[Horizontal][Vertical]**.
2. Capacity: **<Insert gal. (L)>**.
3. Interior Finish: **[Epoxy][Epoxy or galvanized][Galvanized]<Insert coating>** coating.
4. Pressure Rating: **[100 psig (690 kPa)]<Insert value>** minimum.

5. Pressure Regulator Setting: <Insert psig (kPa)>.
6. Pressure Relief Valve Setting: <Insert psig (kPa)>.
7. Drain: [Automatic][Manual] valve.

D. Capacities and Characteristics:

1. Air Compressor(s): [One][Two]<Insert number>; single stage.
2. Standard-Air Capacity of Each Air Compressor: <Insert scfm (standard L/s)> free air.
3. Actual-Air Capacity of Each Air Compressor: <Insert acfm (actual L/s)> delivered.
4. Discharge-Air Pressure: [15 psig (103 kPa)][20 psig (138 kPa)][25 psig (173 kPa)]<Insert value>.
5. Intake-Air Temperature: <Insert deg F (deg C)>.
6. Discharge-Air Temperature: <Insert deg F (deg C)>.
7. Mounting: [Freestanding][Tank mounted].
8. Motor (Each Air Compressor):
 - a. Horsepower: <Insert value>.
 - b. Speed: [1750][3400]<Insert value> rpm.
9. Electrical Characteristics:
 - a. Volts: <Insert value>.
 - b. Phase(s): [Single][Three].
 - c. Hertz: [60]<Insert value>.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

2.10 ROTARY, SLIDING-VANE AIR COMPRESSORS - OIL SEALED

A. Rotary, Sliding-Vane Air Compressors - Oil Sealed :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CompAir, Ltd]
 - b. [Davey Compressor Company]
 - c. [Gast Manufacturing Inc]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CompAir, Ltd]
 - b. [Davey Compressor Company]
 - c. [Gast Manufacturing Inc]
 - d. <Insert manufacturer's name>

B. Compressor(s): Nonpulsating, rotary, sliding-vane type with oil-sealed sliding vanes.

1. Cleanable inlet screens.
2. Outlet silencers and oil-mist separators on discharge connections.

C. Receiver: ASME construction steel tank.

1. Arrangement: **[Horizontal][Vertical]**.
2. Capacity: **<Insert gal. (L)>**.
3. Interior Finish: **[Epoxy][Epoxy or galvanized][Galvanized]<Insert coating>** coating.
4. Pressure Rating: **[100 psig (690 kPa)][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert value>** minimum.
5. Pressure Regulator Setting: **<Insert psig (kPa)>**.
6. Pressure Relief Valve Setting: **<Insert psig (kPa)>**.
7. Drain: **[Automatic][Manual]** valve.

D. Capacities and Characteristics:

1. Air Compressor(s): **[One][Two]<Insert number>**; single stage.
2. Standard-Air Capacity of Each Air Compressor: **<Insert scfm (standard L/s)>** free air.
3. Actual-Air Capacity of Each Air Compressor: **<Insert acfm (actual L/s)>** delivered.
4. Discharge-Air Pressure: **[20 psig (138 kPa)][25 psig (173 kPa)][30 psig (207 kPa)][100 psig (690 kPa)][125 psig (860 kPa)]<Insert value>**.
5. Intake-Air Temperature: **<Insert deg F (deg C)>**.
6. Discharge-Air Temperature: **<Insert deg F (deg C)>**.
7. Mounting: **[Freestanding][Tank mounted]**.
8. Motor (Each Air Compressor):
 - a. Horsepower: **<Insert value>**.
 - b. Speed: **[1750][3400]<Insert value>** rpm.
9. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase(s): **[Single][Three]**.
 - c. Hertz: **[60]<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.11 AIR FILTERS - INLET TYPE

A. Description for Each Compressor: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.

1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
2. Capacity: Match capacity of air compressor, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

B. Description for Multiple Compressors: Combination inlet-air filter-silencer, suitable for remote installation, for multiple air compressors.

1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
2. Capacity: Match total capacity of connected air compressors, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.12 COMPRESSED-AIR AFTERCOOLERS - AIR COOLED

A. Compressed-Air Aftercoolers - Air Cooled :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Aircel]**
 - b. **[AKG Group]**
 - c. **[IPAC, Inc.]**
 - d. **[Kaeser Compressors, Inc]**
 - e. **[Saylor-Beall Manufacturing Company]**
 - f. **[Van Air Systems, Inc]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aircel]**
 - b. **[AKG Group]**
 - c. **[IPAC, Inc.]**
 - d. **[Kaeser Compressors, Inc]**
 - e. **[Saylor-Beall Manufacturing Company]**
 - f. **[Van Air Systems, Inc]**
 - g. **<Insert manufacturer's name>**
- B. Description: Electric-motor-driven, fan-operation, finned-tube unit; rated at **[250 psig (1725 kPa)]<Insert value>** and leak tested at **350 psig (2415 kPa)** minimum air pressure; in capacities indicated. Size units to cool compressed air in compressor-rated capacities to **[10 deg F (6 deg C)]<Insert temperature>** above summertime maximum ambient temperature. Include moisture separator and automatic drain.
- C. Capacities and Characteristics:
1. Standard-Air Capacity of Each Aftercooler: **<Insert scfm (standard L/s)>** free air.
 2. Pressure: **<Insert psig (kPa)>**.
 3. Entering, Compressed-Air Temperature: **<Insert deg F (deg C)>**.
 4. Leaving, Compressed-Air Temperature: **<Insert deg F (deg C)>**.
 5. Ambient-Air Temperature: **<Insert deg F (deg C)>**.
 6. Maximum Compressed-Air-Pressure Drop: **<Insert psig (kPa)>**.
 7. Motor Horsepower: **<Insert value>**.
 8. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase(s): **[Single][Three]**.
 - c. Hertz: **[60]<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.13 COMPRESSED-AIR AFTERCOOLERS - WATER COOLED

A. Compressed-Air Aftercoolers - Water Cooled :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Aircel]**
 - b. **[IPAC, Inc.]**
 - c. **[Kaeser Compressors, Inc]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aircel]**
 - b. **[IPAC, Inc.]**
 - c. **[Kaeser Compressors, Inc]**
 - d. **<Insert manufacturer's name>**

- B. Description: Shell-and-tube unit, rated at **[250 psig (1725 kPa)]<Insert value>** and leak tested at **350 psig (2415 kPa)** minimum air pressure, in capacities indicated. Include moisture separator and automatic drain.

C. Capacities and Characteristics:

1. Standard-Air Capacity of Each Aftercooler: **<Insert scfm (standard L/s)>** free air.
2. Pressure: **<Insert psig (kPa)>**.
3. Entering-Water Temperature: **<Insert deg F (deg C)>**.
4. Water Flow: **<Insert gpm (L/s)>**.
5. Entering, Compressed-Air Temperature: **<Insert deg F (deg C)>**.
6. Leaving, Compressed-Air Temperature: **<Insert deg F (deg C)>**.

2.14 COMPRESSED-AIR DRYERS - REFRIGERANT TYPE

A. Compressed-Air Dryers - Refrigerant Type :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Air/Tak, Inc]**
 - b. **[Atlas Copco]**
 - c. **[FS-Curtis]**
 - d. **[Ingersoll Rand]**
 - e. **[Kaeser Compressors, Inc]**
 - f. **[McIntire Company]**
 - g. **[Parker (Parker Hannifin)]**
 - h. **[Pioneer Air Systems, Inc]**
 - i. **[Pneumatech Inc]**
 - j. **[SPXFLOW, Hankison]**

- k. [Wilkerson Operations]
- l. [Zeks Compressed Air Solutions]
- m. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Air/Tak, Inc]
- b. [Atlas Copco]
- c. [FS-Curtis]
- d. [Ingersoll Rand]
- e. [Kaeser Compressors, Inc]
- f. [McIntire Company]
- g. [Parker (Parker Hannifin)]
- h. [Pioneer Air Systems, Inc]
- i. [Pneumatech Inc]
- j. [SPXFLOW, Hankison]
- k. [Wilkerson Operations]
- l. [Zeks Compressed Air Solutions]
- m. <Insert manufacturer's name>

- B. Description: Noncycling, air-cooled, electric-motor-driven unit with steel enclosure and capability to deliver **35 deg F (2 deg C), 100 psig (690 kPa)** air at dew point. Include automatic ejection of condensate from airstream, step-down transformers, disconnect switches, inlet and outlet pressure gauges, thermometers, automatic controls, and filters.

- C. Capacities and Characteristics:

- 1. Standard-Air Capacity of Each Compressed-Air Dryer: <Insert scfm (standard L/s)> free air.
- 2. Pressure: <Insert psig (kPa)>.
- 3. Entering-Air Temperature: <Insert deg F (deg C)>.
- 4. Leaving-Air Temperature: <Insert deg F (deg C)>.
- 5. Leaving-Air Dew Point Temperature: <Insert deg F (deg C)>.
- 6. Ambient-Air Temperature: <Insert deg F (deg C)>.
- 7. Maximum Air-Pressure Drop: <Insert psig (kPa)>.
- 8. Inlet Filter: [5]<Insert number> micrometers.
- 9. Outlet Filter: [1]<Insert number> micrometer(s).
- 10. Motor Horsepower: <Insert value>.
- 11. Electrical Characteristics:
 - a. Volts: <Insert value>.
 - b. Phase(s): [Single][Three].
 - c. Hertz: [60]<Insert value>.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

2.15 COMPRESSED-AIR DRYERS - DESICCANT TYPE

- A. Compressed-Air Dryers - Desiccant Type :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Air/Tak, Inc]
- b. [Donaldson Company, Inc.]
- c. [Ingersoll Rand]
- d. [Kaeser Compressors, Inc]
- e. [Numatics, Incorporated]
- f. [Parker (Parker Hannifin)]
- g. [Pioneer Air Systems, Inc]
- h. [Pneumatech Inc]
- i. [SPXFLOW, Air Treatment]
- j. [SPXFLOW, Hankison]
- k. [Van Air Systems, Inc]
- l. [Wilkerson Operations]
- m. [Zeks Compressed Air Solutions]
- n. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Air/Tak, Inc]
- b. [Donaldson Company, Inc.]
- c. [Ingersoll Rand]
- d. [Kaeser Compressors, Inc]
- e. [Numatics, Incorporated]
- f. [Parker (Parker Hannifin)]
- g. [Pioneer Air Systems, Inc]
- h. [Pneumatech Inc]
- i. [SPXFLOW, Air Treatment]
- j. [SPXFLOW, Hankison]
- k. [Van Air Systems, Inc]
- l. [Wilkerson Operations]
- m. [Zeks Compressed Air Solutions]
- n. <Insert manufacturer's name>

- B. Description: Twin-tower unit with purge system, mufflers, and capability to deliver [plus 10 deg F (minus 12 deg C), 100 psig (690 kPa)]<Insert values> air at dew point. Include dew point controlled purge, step-down transformers, disconnect switches, inlet and outlet pressure gauges, thermometers, automatic controls, and filters.

- C. Capacities and Characteristics:

1. Standard-Air Capacity of Each Compressed-Air Dryer: <Insert scfm (standard L/s)> free air.
2. Pressure: <Insert psig (kPa)>.
3. Entering-Air Temperature: <Insert deg F (deg C)>.
4. Leaving-Air Temperature: <Insert deg F (deg C)>.
5. Leaving-Air Dew Point Temperature: <Insert deg F (deg C)>.
6. Ambient-Air Temperature: <Insert deg F (deg C)>.
7. Maximum Air-Pressure Drop: <Insert psig (kPa)>.
8. Inlet Filter: [5]<Insert number> micrometers.
9. Outlet Filter: [1]<Insert number> micrometer(s).
10. Electrical Characteristics:

- a. Volts: **<Insert value>**.
- b. Phase(s): **[Single][Three]**.
- c. Hertz: **[60]<Insert value>**.
- d. Full-Load Amperes: **<Insert value>**.
- e. Minimum Circuit Ampacity: **<Insert value>**.
- f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.16 COMPUTER INTERFACE CABINET

A. Description:

1. Wall mounting.
2. Welded steel with white enamel finish.
3. Gasketed door.
4. Grounding device.
5. Factory-installed, signal circuit boards.
6. Power transformer.
7. Circuit breaker.
8. Wiring terminal board.
9. Internal wiring capable of interfacing **[20]<Insert number>** alarm signals.

2.17 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220500 "Common Work Results for Plumbing."

1. Enclosure: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Open, externally ventilated][Totally enclosed, nonventilated][Severe duty][Explosion proof][Dust-ignition-proof machine]**.
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.

B. **<Insert unique motor characteristics>**.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of compressed air piping to verify actual location before air compressor installation.

3.2 INSTALLATION OF EQUIPMENT

A. Equipment Mounting:

1. Install air compressors **[and aftercoolers][and air dryers][, aftercoolers, and air dryers]** on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Install **[water-cooled, compressed-air aftercoolers][and][desiccant compressed-air dryers]**

- on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
3. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
 4. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."
- B. Install compressed-air equipment anchored to substrate.
- C. Arrange equipment so controls and devices are accessible for servicing.
- D. Maintain manufacturer's recommended clearances for service and maintenance.
- E. Install the following devices on compressed-air equipment:
1. Thermometer, Pressure Gauge, and Safety Valve: Install on each compressed-air receiver.
 2. Pressure Regulators: Install downstream from air compressors[**and dryers**].
 3. Automatic Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 221513 "General-Service Compressed-Air Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch** high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 IDENTIFICATION

- A. Identify general-service air compressors and components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Check for lubricating oil in lubricated-type equipment.
 - 3. Check belt drives for proper tension.
 - 4. Verify that air compressor inlet filters and piping are clear.
 - 5. Check for equipment vibration-control supports and flexible pipe connectors, and verify that equipment is properly attached to substrate.
 - 6. Check safety valves for correct settings. Ensure that settings are higher than air compressor discharge pressure, but not higher than rating of system components.
 - 7. Check for proper seismic restraints.
 - 8. Drain receiver tanks.
 - 9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 10. Test and adjust controls and safeties.

3.8 ADJUSTING

- A. Adjust equipment to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust control set points.

3.9 FIELD QUALITY CONTROL

- A. Test Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start unit to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. Air compressors, aftercoolers, air dryers, and controllers will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.



3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain air compressors[**and aftercoolers**][**and air dryers**][, **aftercoolers, and air dryers**].

END OF SECTION 22 15 19 00



THIS PAGE INTENTIONALLY LEFT BLANK



Task	Specification	Specification Description
22 15 19 13	22 15 19 00	General-Service Packaged Air Compressors and Receivers
22 15 19 19	22 15 19 00	General-Service Packaged Air Compressors and Receivers



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 31 00 00 - DOMESTIC WATER SOFTENERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water softeners.
2. Chemicals.
3. Water-testing sets.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water softeners.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for water softeners, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water softeners to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials[, **from the same product run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Salt for Brine Tanks: Furnish in same form as and at least **[four]<Insert number>** times original load, but not less than **[200 (90.7)][1000 (453.6)]<Insert weight> lb (kg)**. Deliver on pallets according to the following:
 - a. Food-Grade Pellet Salt: In **[40- or 50- (18.1- or 22.7-)][80- (36.3-)]<Insert weight> lb (kg)** packages.
 - b. Plain Pellet Salt: In **[40- or 50- (18.1- or 22.7-)][80- (36.3-)]<Insert weight> lb (kg)** packages.
 - c. Crystallized Solar Salt: In **[40- or 50- (18.1- or 22.7-)][80- (36.3-)]<Insert weight> lb (kg)** packages.
 - d. Plain, Brine Block Salt: In **[50- (22.7-)]<Insert weight> lb (kg)** blocks.
 2. Store salt on raised platform where directed by Owner. Do not store in contact with concrete floor.

1.6 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of water softeners that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Structural failures of mineral and brine tanks.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - d. Attrition loss of resin exceeding 3 percent per year.
 - e. Mineral washed out of system during service run or backwashing period.
 - f. Effluent turbidity greater and color darker than incoming water.
 - g. Fouling of underdrain system, gravel, and resin with turbidity or by dirt, rust, or scale from water softener or soft water, while operating according to manufacturer's written operating instructions.
 2. Water Softeners, Warranty Period: From date of Substantial Completion.
 - a. Mineral Tanks: **[Five][10]<Insert number>** years.
 - b. Brine Tanks: **[10]<Insert number>** years.
 - c. Control Valve: **[One]<Insert number>** year(s).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.
- B. Seismic Performance: Water softeners shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **and the unit will be fully operational after the seismic event**."
- C. Capacities and Characteristics:
 - 1. Water Analysis:
 - a. Hardness: **<Insert number> grains/gal. or ppm (mg/L).**
 - b. Iron: **<Insert number> ppm (mg/L).**
 - c. Dissolved Solids: **<Insert number> ppm (mg/L).**
 - d. Concentration: **<Insert pH>**.
 - e. Inlet Water Pressure: **<Insert number> psig (kPa).**
 - f. Water Temperature: **<Insert number> deg F (deg C).**
 - 2. Continuous Service Flow Rate: **<Insert number> gpm at 15-psig (L/s at 104-kPa) pressure drop.**
 - 3. Peak Service Flow Rate: **<Insert number> gpm at 25-psig (L/s at 173-kPa) pressure drop.**
 - 4. Water Meter Size: **<Insert number> NPS (DN).**
 - 5. Manifold Pipe Size: **<Insert number> NPS (DN).**
 - 6. Backwash-to-Drain Pipe Size: **<Insert number> NPS (DN).**
 - 7. Water Consumption: **<Insert number> gal./day (cu. m/day).**
 - 8. Water Demand: **<Insert hours/day>**.
 - 9. Number of Mineral Tanks: **[One][Two][Three]<Insert number>**.
 - 10. Mineral Quantity, Each Tank: **<Insert number> cu. ft. (cu. m).**
 - 11. Mineral Exchange Capacity: **<Insert number> grains/cu. ft. per lb (kg/cu. m per kg) of salt.**
 - 12. Electrical Characteristics:
 - a. Volts: **<Insert number> V.**
 - b. Phases: **<Insert number>**.
 - c. Hertz: **<Insert number> Hz.**
 - d. Full-Load Amperes: **<Insert number> A.**
 - e. Minimum Circuit Ampacity: **<Insert number> A.**
 - f. Maximum Overcurrent Protection: **<Insert number> A.**
 - 13. Salt Capacity: **<Insert number> lb (kg).**
 - 14. Minimum Number of Regenerations per Refill: **<Insert number>**.
 - 15. Floor Area Required: **<Insert number> sq. ft. (sq. m).**
 - 16. Height Required: **<Insert number> inches (mm).**

2.2 WATER SOFTENERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be**

incorporated into the Work include, but are not limited to, the following]:

1. [3M]
2. [Aquion, Inc.]
3. [Culligan International Company]
4. [Diamond Water Conditioning; a Griesbach company]
5. [Ecodyne Limited]
6. [Hungerford & Terry, Inc.]
7. [Kinetico Incorporated]
8. [Marlo Incorporated]
9. [Parker Boiler]
10. [Springsoft International, Inc.]
11. [Water King]
12. [WaterSoft]
13. [WATTS; A Watts Water Technologies Company]
14. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [3M]
2. [Aquion, Inc.]
3. [Culligan International Company]
4. [Diamond Water Conditioning; a Griesbach company]
5. [Ecodyne Limited]
6. [Hungerford & Terry, Inc.]
7. [Kinetico Incorporated]
8. [Marlo Incorporated]
9. [Parker Boiler]
10. [Springsoft International, Inc.]
11. [Water King]
12. [WaterSoft]
13. [WATTS; A Watts Water Technologies Company]
14. <Insert manufacturer's name>

C. Description: Factory-assembled, pressure-type water softener.

1. Configuration: [Single unit with one mineral tank][Twin unit with two mineral tanks][Triple unit with three mineral tanks]<Insert configuration> and one brine tank.
2. Mounting: On skids.
3. Wetted Components: Suitable for water temperatures from [40 to at least 100 deg F (5 to at least 38 deg C)][40 to at least 120 deg F (5 to at least 49 deg C)][40 to at least 150 deg F (5 to at least 66 deg C)]<Insert temperature>.
4. Mineral Tanks, FRP: Pressure-vessel quality.
 - a. Construction: [Non-ASME code.][Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section X, "Fiber-Reinforced Plastic Pressure Vessels."]
 - b. Pressure Rating: [100 (690)][125 (860)]<Insert pressure> psig (kPa) minimum.
 - c. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
 - d. Support Legs or Skirt: Constructed of structural steel, welded to tank[before testing and labeling].
 - e. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
 - f. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from nonmetallic pipe and fittings with individual, fine-slotted, nonclogging plastic strainers, and

- g. arranged for even flow distribution through resin bed.
Liner: PE, ABS, or other material suitable for potable water.
5. Mineral Tanks, **[Steel][Stainless Steel]**: Electric welded; pressure-vessel quality.
 - a. Seismic Requirements: Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
 - b. Construction: **[Non-ASME code.][Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.]**
 - c. Pressure Rating: **[100 (690)][125 (860)][150 (1035)]<Insert pressure> psig (kPa)** minimum.
 - d. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
 - e. Handholes: **4 inches (102 mm)** round or **4 by 6 inches (102 by 152 mm)** elliptical, in top head and lower sidewall of tanks **[30 (762)]<Insert dimension> inches (mm)** and smaller in diameter.
 - f. Manhole: **11 by 15 inches (280 by 380 mm)** in top head of tanks larger than **[30 (762)]<Insert dimension> inches (mm)** in diameter.
 - g. Support Legs or Skirt: Constructed of structural steel, welded to tank **[before testing and labeling]**.
 - h. Finish:
 - 1) Hot-dip galvanized on exterior and interior of tank after fabrication unless tank is stainless steel.
 - 2) Exterior of tank spray-painted with rust-resistant prime coat, **2- to 3-mil (0.051- to 0.076-mm)** dry film thickness. Interior sandblasted and lined with epoxy-polyamide coating, **8- to 10-mil (0.203- to 0.254-mm)** dry film thickness.
 - i. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
 - j. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers, and arranged for even flow distribution through resin bed.
 - k. Liner: PE, ABS, or other material suitable for potable water.
6. Controls, Automatic: **[120]<Insert number> V**; factory wired and factory mounted on unit.
 - a. Adjustable duration of various regeneration steps.
 - b. Push-button start and complete manual operation.
 - c. Electric time clock and switch for automatic operation except for manual return to service.
 - d. Sequence of Operation: Multiport pilot-control valve automatically pressure-actuates main operating valve through steps of regeneration.
 - e. Pointer on pilot-control valve shall indicate cycle of operation.
 - f. Includes means of manual operation of pilot-control valve if power fails.
7. Controls, Fully Automatic: **[120]<Insert number> V**; factory wired and factory mounted on unit.
 - a. Adjustable duration of various regeneration steps.
 - b. Push-button start and complete manual operation.
 - c. Electric time clock and switch for fully automatic operation, adjustable to initiate regeneration at any hour of day and any day of week or at fixed intervals.
 - d. Sequence of Operation: Multiport pilot-control valve automatically pressure-actuates main operating valve through steps of regeneration and return to service.
 - e. Pointer on pilot-control valve shall indicate cycle of operation.
 - f. Includes means of manual operation of pilot-control valve if power fails.

8. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:
 - a. Slow opening and closing, nonslam operation.
 - b. Diaphragm guiding on full perimeter from fully open to fully closed.
 - c. Isolated, dissimilar metals within valve.
 - d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
 - e. Valve for single mineral-tank unit with internal automatic bypass of raw water during regeneration.
 - f. Sampling cocks for soft water.
 - g. Special tools are not required for service.
9. Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressure; does not require field adjustments.
 - a. Meter Control: Each mineral tank is equipped with signal-register-head water meter that produces electrical signal indicating need for regeneration on reaching hand-set total in **gallons (liters)**. Signal will continue until reset.
 - b. Demand-Initiated Control:
 - 1) Single mineral tank is equipped with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in **gallons (liters)**. Head automatically resets to preset total in **gallons (liters)** for next service run.
 - 2) Each mineral tank of twin mineral-tank unit is equipped with automatic-reset-head water meter that electrically activates cycle controllers to initiate regeneration at preset total in **gallons (liters)**. Head automatically resets to preset total in **gallons (liters)** for next service run. Electrical lockout prevents simultaneous regeneration of both tanks.
 - 3) Each twin mineral-tank unit is equipped with automatic-reset-head water meter, in common outlet header, that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in **gallons (liters)** and divert flow to other tank. Automatically repeats with other tank. Electrical lockout prevents simultaneous regeneration of both tanks.
 - 4) Each mineral tank of multiple mineral-tank unit is equipped with automatic-reset-head water meter that electrically activates cycle controllers to automatically regenerate at preset total in **gallons (liters)**. Head automatically resets to preset total in **gallons (liters)** for next service run. Electrical lockout prevents simultaneous regeneration of more than one tank.
 - 5) Each multiple mineral-tank unit is equipped with automatic-reset-head water meter, in common outlet header, that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in **gallons (liters)** and divert flow to other tanks. Automatically repeats with other tanks. Electrical lockout prevents simultaneous regeneration of more than one tank.
10. Brine Tank: Combination measuring and wet-salt storing system.
 - a. Tank and Cover Material: Fiberglass, **3/16 inch (4.8 mm)** thick; or molded PE, **3/8 inch (9.5 mm)** thick.
 - b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawal and freshwater refill.
 - c. Size: Large enough for at least four regenerations at full salting.
11. Factory-Installed Accessories:

- a. Piping, valves, tubing, and drains.
- b. Sampling cocks.
- c. Main-operating-valve position indicators.
- d. Water meters.

2.3 CHEMICALS

- A. Mineral: High-capacity, sulfonated-polystyrene, ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.
 - 1. Exchange Capacity: **[30,000 (69)]<Insert capacity> grains/cu. ft. (kg.cu. m)** of calcium carbonate of resin when regenerated with **15 lb (6.8 kg)** of salt.
- B. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are unacceptable.
 - 1. Form: Processed, **[food-grade salt pellets][plain salt pellets][crystallized solar salt collected from shallow ponds and milled into irregular particles][plain, brine block salt]**.

2.4 WATER-TESTING SETS

- A. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

2.5 SOURCE QUALITY CONTROL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. ASME Compliance for Steel Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, where indicated.
- C. ASME Compliance for FRP Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, where indicated.
- D. UL Compliance: Fabricate and label water softeners to comply with UL 979, "Water Treatment Appliances."
- E. Hydrostatically test mineral tanks before shipment to a minimum of one and one-half times the pressure rating.
- F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF WATER SOFTENERS

- A. Equipment Mounting:
 - 1. Install water softeners on cast-in-place concrete equipment base(s). Comply with requirements

- for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- 3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

- B. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure.
- C. Install brine lines and fittings furnished by equipment manufacturer, but not specified to be factory installed.
- D. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.
- E. Install water-testing sets mounted on wall, unless otherwise indicated, and near water softeners.

3.2 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.
- C. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank[, **and on inlet and outlet headers**].
 - 1. Metal general-duty valves are specified in Section 220523 "General-Duty Valves for Plumbing Piping."
 - 2. Plastic valves are specified in Section 221116 "Domestic Water Piping."
 - 3. Exception for water softeners with factory-installed shutoff valves at locations indicated.
- D. Install pressure gauges on raw-water inlet and soft-water outlet piping of each mineral tank. Pressure gauges are specified in Section 220500 "Common Work Results for Plumbing."
 - 1. Exception for water softeners with factory-installed pressure gauges at locations indicated.
 - 2. Exception for household water softeners.
 - 3. Exception for water softeners in hot-water service.
- E. Install valved bypass in water piping around water softeners.
 - 1. Metal general-duty valves are specified in Section 220523 "General-Duty Valves for Plumbing Piping."
 - 2. Plastic valves are specified in Section 221116 "Domestic Water Piping."
 - 3. Water piping is specified in Section 221116 "Domestic Water Piping."
 - 4. Exception for water softeners in hot-water service.
- F. Install indirect wastes to spill into open drains or pit with drain.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.4 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Water softeners will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
- B. Add water to brine tanks and fill with the following form of salt:
 - 1. Water Softeners: Processed, **[plain salt pellets][crystallized solar salt collected from shallow ponds and milled into irregular particles][plain, brine block salt]<Insert salt form>**.
- C. Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics. Comply with the following:
 - 1. ASTM D859, "Test Method for Silica in Water."
 - 2. ASTM D1067, "Test Methods for Acidity or Alkalinity of Water."

3. ASTM D1068, "Test Methods for Iron in Water."
4. ASTM D1126, "Test Method for Hardness in Water."
5. ASTM D1129, "Terminology Relating to Water."
6. ASTM D3370, "Practices for Sampling Water from Closed Conduits."

3.7 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include ~~[three]~~~~[six]~~~~[nine]~~**[12]** months' full maintenance by skilled employees of water softener Installer. Include ~~[monthly]~~~~[quarterly]~~ preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper water softener operation at rated capacity. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
- B. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

3.8 DEMONSTRATION

- A. ~~[Engage a factory-authorized service representative to train]~~**[Train]** Owner's maintenance personnel to adjust, operate, and maintain domestic water softeners.

END OF SECTION 22 31 00 00



Task	Specification	Specification Description
22 31 13 00	22 31 00 00	Domestic Water Softeners



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 31 16 00 - WATER TREATMENT PLANT ELECTRICAL CONTROLS AND INSTRUMENTATION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of water treatment plant electrical controls and instrumentation. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. General

1. Items not specified but required for the proper installation or repair of a specified item of work shall be provided. Items shall be of proper type, size, design, and characteristics for the use intended. Parts shall be factory-made.

B. Finishes

1. Items replacing existing items that are galvanized, plated, painted, or otherwise finished shall be finished with like finish in compliance with the manufacturer's standard practice.

C. Electrical Controls and Instrumentation Components

1. Components for replacement purposes shall be designed for same service as the existing.

1.3 EXECUTION

A. Coordination

1. Contractor shall determine that requirements for removal of the equipment from service, the bypassing of control valves, and installing of temporary replacements have been coordinated with the the Owner. Bypassing of control valves or putting a control instrument in the Remote-Hand-Control mode will be done by the plant operators.

B. Power Supplies

1. Units that may be a hazard during the performance of the work shall be locked out.

C. Testing

1. Check the operation of each instrument after it is returned to service. Adjust each instrument to operate properly over the design range.

END OF SECTION 22 31 16 00



THIS PAGE INTENTIONALLY LEFT BLANK



Task	Specification	Specification Description
22 31 16 00	22 31 00 00	Domestic Water Softeners



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 32 00 00 - DOMESTIC WATER FILTRATION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Filters - bag type.
2. Filters - cartridge type, freestanding.
3. Filters - cartridge type, off floor.
4. Filters - carbon type.
5. Filters - sand type, circulating.
6. Filters - sand type, multimedia.
7. Filters - greensand type.
8. Separators.

B. Related Requirements:

1. Section 221119 "Domestic Water Piping Specialties" for plumbing piping strainers.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Filters - bag type.
2. Filters - cartridge type, freestanding.
3. Filters - cartridge type, off floor.
4. Filters - carbon type.
5. Filters - sand type, circulating.
6. Filters - sand type, multimedia.
7. Filters - greensand type.
8. Separators.

B. Product Data Submittals: For each product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Shop Drawings: For water filtration equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For **[bag-type filters],[freestanding cartridge-type filters],[carbon-type filters],[circulating sand-type filters],[multimedia sand-type filters],[greensand-type filters],[separators,]** accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Certificates of Shop Inspections and Data Reports: For products required to have ASME label, signed by product manufacturer.
- C. Welding certificates.
- D. Source quality-control reports.
- E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For water filtration equipment to include in emergency, operation, and maintenance manuals.
 - 1. Indicate the actual installed items by marking the submittals with an arrow or box.

1.5 MATERIALS MAINTENANCE SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Bag-Type Filter Bags: Bags for bag-type filters equal to **[200][400]<Insert number>** percent of amount installed for each size and media indicated.
 - 2. Cartridge-Filter Elements: Elements for cartridge filters equal to **[200][400]<Insert number>** percent of amount installed for each size and media indicated.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify processes and operators in accordance with ASME Boiler and Pressure Vessel Code.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.7 PROJECT CONDITIONS

- A. Feedwater Analysis:

1. Alkalinity: <Insert ppm (mg/L)>.
2. Arsenic: <Insert ppm (mg/L)>.
3. Calcium: <Insert ppm (mg/L)>.
4. Chlorine: <Insert ppm (mg/L)>.
5. Color: <Insert nephelometric turbidity units>.
6. Hydrogen-Ion Concentration: <Insert pH>.
7. Hardness: <Insert ppm (mg/L)>.
8. Hydrogen Sulfide: <Insert ppm (mg/L)>.
9. Iron: <Insert ppm (mg/L)>.
10. Lead: <Insert ppm (mg/L)>.
11. Magnesium: <Insert ppm (mg/L)>.
12. Manganese: <Insert ppm (mg/L)>.
13. Potassium: <Insert ppm (mg/L)>.
14. Sand: <Insert ppm (mg/L)>.
15. Silt: <Insert ppm (mg/L)>.
16. Sodium: <Insert ppm (mg/L)>.
17. Total Dissolved Solids: <Insert ppm (mg/L)>.
18. Turbidity: <Insert ppm (mg/L)>.
19. <Insert characteristic>: <Insert value>.

B. Feedwater Properties:

1. Inlet Water Pressure: <Insert psig (kPa)>.
2. Water Temperature: <Insert deg F (deg C)>.

1.8 COORDINATION

- A. Coordinate size and location of concrete bases with actual equipment provided.

1.9 WARRANTY

- A. Manufacturer Warranty: [Manufacturer agrees][Installer agrees][Manufacturer and Installer agree] to repair or replace water filtration components that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: [1]<Insert number> year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of water filtration equipment through one source from a single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Domestic water filtration equipment intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act, with requirements of authorities having jurisdiction, and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

- B. Seismic Performance: **[Bag-type filters,][Freestanding cartridge-type filters,][Carbon-type filters,][Circulating sand-type filters,][Multimedia sand-type filters,][Greensand-type filters,][and][separators]** is to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>** See Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

1. The term "withstand" means that "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"
2. Component Importance Factor: **[1.5][1.0].**
3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>.**

2.3 FILTERS - BAG TYPE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Filtration Systems; Mechanical Mfg. Corporation]**
2. **[Hayward Flow Control; Hayward Industries, Inc.]**
3. **[Parker (Parker Hannifin)]**
4. **[PEP Filters, Inc.]**
5. **[Rosedale Products, Inc.]**
6. **[Shelco Filters]**
7. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Filtration Systems; Mechanical Mfg. Corporation]**
2. **[Hayward Flow Control; Hayward Industries, Inc.]**
3. **[Parker (Parker Hannifin)]**
4. **[PEP Filters, Inc.]**
5. **[Rosedale Products, Inc.]**
6. **[Shelco Filters]**
7. **<Insert manufacturer's name>**

- C. Description: Simplex, floor-mounted housing with **[single-bag filter][multiple-bag filter]** for removing suspended particles from water.

1. Housing: Corrosion resistant; designed to separate feedwater from filtrate and to direct feedwater through bag-type water filter(s); with bag support and base, feet, or skirt.
 - a. Material: **[Carbon steel with NSF 61/NSF 372 lining material][Plastic][Stainless steel].**
 - b. Seals: **[NBR]<Insert material>.**
 - c. Bag Support: Top lock ring and perforated **[stainless steel]<Insert material>** basket.
 - d. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - e. Steel Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606. Provide stainless steel flanges if housing is stainless steel.
 - f. Plastic Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: **150 psig (1035 kPa)** plastic flanges.

2. Bag: Replaceable, of shape to fit housing.

D. Capacity and Characteristics:

1. Filtrate Design Concentrations:

- a. Alkalinity: **<Insert ppm (mg/L)>**.
- b. Chlorine: **<Insert ppm (mg/L)>**.
- c. Color: **<Insert nephelometric turbidity units>**.
- d. Hydrogen Sulfide: **<Insert ppm (mg/L)>**.
- e. Iron: **<Insert ppm (mg/L)>**.
- f. Manganese: **<Insert ppm (mg/L)>**.
- g. Sand: **<Insert ppm (mg/L)>**.
- h. Silt: **<Insert ppm (mg/L)>**.
- i. Turbidity: **<Insert ppm (mg/L)>**.
- j. **<Insert characteristic>**: **<Insert value>**.

2. Filter Design:

- a. Continuous Flow: **<Insert gpm (L/s)>**.
- b. Peak Flow: **<Insert gpm (L/s)>**.
- c. Filtration Efficiency: **[98]<Insert number>** percent retention of suspended particles **[10][20]<Insert size>** microns and larger from feedwater of listed filtrate design concentrations.
- d. Pressure Drop, Clean: Not to exceed **[2 psig (14 kPa)]<Insert value>** at filter design flow rate when clean.
- e. Pressure Drop, Dirty: Not to exceed **<Insert value>** when dirty.

3. Housing:

- a. Pressure Rating: **<Insert psig (kPa)>**.
- b. Diameter: **<Insert inches (mm)>**.
- c. Height or Length: **<Insert inches (mm)>**.
- d. Inlet and Outlet Size: **<Insert NPS (DN)>**.
- e. Drain Size: **[Not applicable]<Insert NPS (DN)>**.

4. Bag:

- a. Nominal Diameter: **<Insert inches (mm)>**.
- b. Nominal Length: **<Insert inches (mm)>**.
- c. Media: **[Cotton][Polyester][PP]<Insert material>**; **[felt, filament, or mesh][felt][filament][mesh]** construction.

2.4 FILTERS - CARTRIDGE TYPE

A. Filters - Cartridge Type, Freestanding:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Campbell Manufacturing, Inc]**
- b. **[Eden Equipment Company]**
- c. **[Graver Technologies]**

- d. [Harmsco, Inc.]
 - e. [Parker (Parker Hannifin)]
 - f. [Porvair Filtration Group]
 - g. [Rosedale Products, Inc.]
 - h. [Serfilco, Ltd]
 - i. [Shelco Filters]
 - j. [Suez Water Technologies (Formerly GE Water)]
 - k. [WATTS; A Watts Water Technologies Company]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Campbell Manufacturing, Inc]
 - b. [Eden Equipment Company]
 - c. [Graver Technologies]
 - d. [Harmsco, Inc.]
 - e. [Parker (Parker Hannifin)]
 - f. [Porvair Filtration Group]
 - g. [Rosedale Products, Inc.]
 - h. [Serfilco, Ltd]
 - i. [Shelco Filters]
 - j. [Suez Water Technologies (Formerly GE Water)]
 - k. [WATTS; A Watts Water Technologies Company]
 - l. <Insert manufacturer's name>
3. Description: Simplex, floor-mounted housing with replaceable element(s) for removing suspended particles from water.
 - a. Housing: Corrosion resistant; designed to separate feedwater from filtrate and to direct feedwater through water filter element(s); with element support(s) and base, feet, or skirt.
 - 1) Fabricate supports and base, feet, or skirt and attachment to housing with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.
 - 2) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - 3) Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606. Provide stainless steel flanges if housing is stainless steel.
 - 4) Plastic Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: **150 psig (1035 kPa)** plastic flanges.
 - b. Element(s): Replaceable; of shape to fit housing.
4. Capacity and Characteristics:
 - a. Filtrate Design Concentrations:
 - 1) Alkalinity: <Insert ppm (mg/L)>.
 - 2) Chlorine: <Insert ppm (mg/L)>.
 - 3) Color: <Insert nephelometric turbidity units>.
 - 4) Hydrogen Sulfide: <Insert ppm (mg/L)>.
 - 5) Iron: <Insert ppm (mg/L)>.

- 6) Manganese: <Insert ppm (mg/L)>.
- 7) Sand: <Insert ppm (mg/L)>.
- 8) Silt: <Insert ppm (mg/L)>.
- 9) Turbidity: <Insert ppm (mg/L)>.
- 10) <Insert characteristic>: <Insert value>.

b. Filter Design:

- 1) Continuous Flow: <Insert gpm (L/s)>.
- 2) Peak Flow: <Insert gpm (L/s)>.
- 3) Filtration Efficiency: [98]<Insert number> percent retention of suspended particles [1][10][20]<Insert size> microns and larger from feedwater of listed filtrate design concentrations.
- 4) Pressure Drop, Clean: Not to exceed [2 psig (14 kPa)]<Insert value> at filter design flow rate when clean.
- 5) Pressure Drop, Dirty: Not to exceed <Insert value> when dirty.

c. Housing:

- 1) Material: [Plastic][Stainless steel]<Insert material>.
- 2) Pressure Rating: <Insert psig (kPa)>.
- 3) Seals: [NBR]<Insert material>.
- 4) Diameter: <Insert inches (mm)>.
- 5) Height or Length: <Insert inches (mm)>.
- 6) Inlet and Outlet Size: <Insert NPS (DN)>.
- 7) Drain Size: [Not applicable]<Insert NPS (DN)>.

d. Elements:

- 1) Number Required: [One][Two]<Insert number>.
- 2) Nominal Diameter: <Insert inches (mm)>.
- 3) Nominal Length: <Insert inches (mm)>.
- 4) Media:
 - a) [Activated charcoal][or][ground charcoal].
 - b) [Pleated polyester][or][pleated PP].
 - c) [Wound polyester][or][wound PP].
 - d) <Insert material>.

B. Filters - Cartridge Type, Off Floor:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Campbell Manufacturing, Inc]
 - b. [Culligan International Company]
 - c. [Eagle Spring Filtration, Inc]
 - d. [Everpure; a brand of Pentair, Inc.]
 - e. [Filpro Corporation]
 - f. [Filtrete Home Filtration Products; a 3M brand]
 - g. [Graver Technologies]
 - h. [Harmsco, Inc.]
 - i. [Hydro Systems International]
 - j. [Matterhorn Filter Corp.]

- k. [Omnipure Filter Company]
 - l. [Parker (Parker Hannifin)]
 - m. [Pentair Filtration, Inc.]
 - n. [Porvair Filtration Group]
 - o. [Shelco Filters]
 - p. [WATTS; A Watts Water Technologies Company]
 - q. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Campbell Manufacturing, Inc]
 - b. [Culligan International Company]
 - c. [Eagle Spring Filtration, Inc]
 - d. [Everpure; a brand of Pentair, Inc.]
 - e. [Filpro Corporation]
 - f. [Filtrete Home Filtration Products; a 3M brand]
 - g. [Graver Technologies]
 - h. [Harmsco, Inc.]
 - i. [Hydro Systems International]
 - j. [Matterhorn Filter Corp.]
 - k. [Omnipure Filter Company]
 - l. [Parker (Parker Hannifin)]
 - m. [Pentair Filtration, Inc.]
 - n. [Porvair Filtration Group]
 - o. [Shelco Filters]
 - p. [WATTS; A Watts Water Technologies Company]
 - q. <Insert manufacturer's name>
3. Description: Simplex, [in-line][wall-mounted] housing with replaceable element for removing suspended particles from water.
 - a. Housing: Corrosion resistant; designed to separate feedwater from filtrate and to direct feedwater through water filter element; with element support.
 - 1) Pipe Connections: Threaded in accordance with ASME B1.20.1.
 - 2) Support: Wall bracket.
 - b. Element: Replaceable; of shape to fit housing.
4. Capacity and Characteristics:
 - a. Filtrate Design Concentrations:
 - 1) Alkalinity: <Insert ppm (mg/L)>.
 - 2) Chlorine: <Insert ppm (mg/L)>.
 - 3) Color: <Insert nephelometric turbidity units>.
 - 4) Hydrogen Sulfide: <Insert ppm (mg/L)>.
 - 5) Iron: <Insert ppm (mg/L)>.
 - 6) Manganese: <Insert ppm (mg/L)>.
 - 7) Sand: <Insert ppm (mg/L)>.
 - 8) Silt: <Insert ppm (mg/L)>.
 - 9) Turbidity: <Insert ppm (mg/L)>.
 - 10) <Insert characteristic>: <Insert value>.

b. Filter Design:

- 1) Continuous Flow: **<Insert gpm (L/s)>**.
- 2) Peak Flow: **<Insert gpm (L/s)>**.
- 3) Filtration Efficiency: **[98]<Insert number>** percent retention of suspended particles **[1][10][20]<Insert size>** microns and larger from feedwater of listed filtrate design concentrations.
- 4) Pressure Drop, Clean: Not to exceed **[2 psig (14 kPa)]<Insert value>** at filter design flow rate when clean.
- 5) Pressure Drop, Dirty: Not to exceed **<Insert value>** when dirty.

c. Housing:

- 1) Material: **[PE or PP][Plastic][Stainless steel]<Insert material>**.
- 2) Pressure Rating: **<Insert psig (kPa)>**.
- 3) Seals: **[NBR]<Insert material>**.
- 4) Diameter: **<Insert inches (mm)>**.
- 5) Height or Length: **<Insert inches (mm)>**.
- 6) Inlet and Outlet Size: **<Insert NPS (DN)>**.
- 7) Drain Size: **[Not applicable]<Insert NPS (DN)>**.

d. Element:

- 1) Nominal Diameter: **<Insert inches (mm)>**.
- 2) Nominal Length: **<Insert inches (mm)>**.
- 3) Media:
 - a) **[Activated charcoal][or][ground charcoal]**.
 - b) **[Pleated polyester][or][pleated PP]**.
 - c) **[Wound polyester][or][wound PP]**.
 - d) **<Insert material>**.

2.5 FILTERS - CARBON TYPE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Chandler Systems, Inc.]**
2. **[Diamond H2O]**
3. **[EcoWater Systems LLC]**
4. **[Marlo Incorporated]**
5. **[Water-Right, Inc.]**
6. **[WATTS; A Watts Water Technologies Company]**
7. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Chandler Systems, Inc.]**
2. **[Diamond H2O]**
3. **[EcoWater Systems LLC]**
4. **[Marlo Incorporated]**
5. **[Water-Right, Inc.]**
6. **[WATTS; A Watts Water Technologies Company]**

7. <Insert manufacturer's name>

- C. Description: Simplex carbon-type filter, with media tank, media, and automatic backwash for [removing chlorine from][and][improving color, odor, and taste of]<Insert application> water.

1. Media Tank: Corrosion resistant with distribution system and media.

a. Construction:

- 1) Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
- 2) Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code, Section X, if indicated.
- 3) Fabricate supports, base, and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.
- 4) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
- 5) Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606. Provide stainless steel flanges if tank is stainless steel.
- 6) FRP Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Type A, integral; **[Designation E, 125 psig (0.862 MPa)][or][Designation F, 150 psig (1.034 MPa)]** pressure category flanges of grade same as tank material in accordance with ASTM D5421.
- 7) Support: Base, feet, or skirt.

2. Controls: Automatic for control of backwash; factory wired for single, external electrical connection.

- a. Panel: NEMA 250, **[Type 4]<Insert type>** enclosure.
- b. Backwash Initiation Device: **[Differential pressure gauges][Electric time clock][Water meter]**.

D. Capacity and Characteristics:

1. Filtrate Design Concentrations:

- a. Alkalinity: **<Insert ppm (mg/L)>**.
- b. Chlorine: **<Insert ppm (mg/L)>**.
- c. Color: **<Insert nephelometric turbidity units>**.
- d. Hydrogen-Ion Concentration: **<Insert pH>**.
- e. Hydrogen Sulfide: **<Insert ppm (mg/L)>**.
- f. Iron: **<Insert ppm (mg/L)>**.
- g. Manganese: **<Insert ppm (mg/L)>**.
- h. Total Dissolved Solids: **<Insert ppm (mg/L)>**.
- i. Turbidity: **<Insert ppm (mg/L)>**.
- j. **<Insert characteristic>: <Insert value>**.

2. Filter Design:

- a. Continuous Flow: **<Insert gpm (L/s)>**.
- b. Flow Rate: **<Insert gpm/sq. ft. (L/s per sq. m)>** of media cross-sectional area.
- c. Peak Flow: **<Insert gpm (L/s)>**.
- d. Filtration Efficiency: **[98]<Insert number>** percent retention of suspended particles

- [20][40]<Insert size> microns and larger from feedwater of listed filtrate design concentrations.
 - e. Pressure Drop, Clean: Not to exceed [2 psig (14 kPa)]<Insert value> at filter design flow rate when clean.
 - f. Pressure Drop, Dirty: Not to exceed <Insert value> when dirty.
 - g. Backwash Flow: <Insert gpm (L/s)>.
- 3. Filter Backwash Interval:
 - a. <Insert psig (kPa)> pressure drop measured by differential pressure gauges.
 - b. <Insert number> days measured by time clock.
 - c. <Insert gal. (cu. m)> measured by water meter.
- 4. Media Tank:
 - a. Material: [Carbon steel with NSF 61/NSF 372 lining material][FRP][Stainless steel].
 - b. Pressure Rating: <Insert psig (kPa)>.
 - c. Media: [Activated charcoal][Ground charcoal]<Insert material>.
 - d. Media Quantity: <Insert cu. ft. (cu. m)>.
 - e. Diameter: <Insert inches (mm)>.
 - f. Height: <Insert inches (mm)>.
 - g. Inlet and Outlet Size: <Insert NPS (DN)>.
- 5. Unit Electrical Characteristics:
 - a. Volts: [120][240][277][480]<Insert value>.
 - b. Phase: [Single][Three].
 - c. Hertz: [60]<Insert value>.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

2.6 FILTERS - SAND TYPE

A. Filters - Sand Type, Circulating:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Diamond H2O]
 - b. [Everfilt]
 - c. [Miami Filter, Inc.]
 - d. [PEP Filters, Inc.]
 - e. [Puroflux Corporation]
 - f. [United Industries, Inc; Tower-flo Water Systems]
 - g. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Diamond H2O]
 - b. [Everfilt]

- c. **[Miami Filter, Inc.]**
 - d. **[PEP Filters, Inc.]**
 - e. **[Puroflux Corporation]**
 - f. **[United Industries, Inc; Tower-flo Water Systems]**
 - g. **<Insert manufacturer's name>**
3. Description: Factory-fabricated and -tested, simplex, sand-filter system of filter tank, media, strainer, circulating pump, piping, and controls for removing sediment particles from water.
- a. Filter Tank: Corrosion resistant with distribution system and media.
 - 1) Construction:
 - a) Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
 - b) Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code, Section X, if indicated.
 - c) Fabricate supports, base, and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.
 - 2) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - 3) Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606.
 - 4) FRP Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Type A, integral; **[Designation E, 125 psig (0.862 MPa)]****[or]****[Designation F, 150 psig (1.034 MPa)]** pressure category flanges of grade same as tank material in accordance with ASTM D5421.
 - b. Strainer: Basket type.
 - 1) Pipe Connections:
 - a) Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - b) Connections NPS 2-1/2 (DN 65) and Larger: Cast-iron, Class 125 flanges in accordance with ASME B16.1.
 - c. Piping:
 - 1) **[Galvanized steel pipe, galvanized cast-iron fittings]****[Stainless steel pipe, stainless steel fittings]**, and flanged, grooved, or threaded joints.
 - 2) **ASTM B88, Type L (ASTM B88M, Type B)** copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
 - d. Safety Valves: Automatic and manual pressure relief.
 - e. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
 - 1) Pump Construction: Bronze fitted.
 - a) Casing: Radially split, cast iron.
 - b) Pressure Rating: **[125 psig (860 kPa)]****[150 psig (1035 kPa)]** minimum.

- c) Impeller: ASTM B584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
 - d) Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
 - e) Seal: Mechanical.
 - 2) Motor: General requirements for motors are specified in Section 220500 "Common Work Results for Plumbing."
 - f. Controls: Automatic for control of circulating pump and tank backwash; factory wired for single, external electrical connection.
 - 1) Panel: NEMA 250, **[Type 4]<Insert type>** enclosure with time clock and pressure gauges.
 - 2) Pump: Automatic and manual.
 - 3) Backwash: Automatic; with **[time-clock][differential-pressure-switch]** initiation device.
 - 4) Backwash Valve: Tank mounted.
 - g. Support: Skid mounting.
4. Capacity and Characteristics:
- a. Filtrate Design Concentrations:
 - 1) Sand: **<Insert ppm (mg/L)>**.
 - 2) Silt: **<Insert ppm (mg/L)>**.
 - 3) **<Insert characteristic>**: **<Insert value>**.
 - b. Filter Design:
 - 1) Continuous Flow: **<Insert gpm (L/s)>** at **[5 psig (34.5 kPa)]<Insert value>** pressure drop.
 - 2) Flow Rate: **<Insert gpm/sq. ft. (L/s per sq. m)>** of media cross-sectional area.
 - 3) Peak Flow: **<Insert gpm (L/s)>**.
 - 4) Filtration Efficiency: **[98]<Insert number>** percent removal of **[1.8]<Insert number>** minimum specific-gravity suspended particles **[5][10][20][45]<Insert size>** microns and larger from feedwater of listed filtrate design concentrations.
 - c. Filter Tank: With internal distribution piping.
 - 1) Material: **[Carbon steel with NSF 61/NSF 372 lining material][FRP]<Insert material>**.
 - 2) Pressure Rating: **<Insert psig (kPa)>**.
 - 3) Diameter: **<Insert inches (mm)>**.
 - 4) Height: **<Insert inches (mm)>**.
 - 5) Inlet and Outlet Size: **<Insert NPS (DN)>**.
 - 6) Purge Size: **<Insert NPS (DN)>**.
 - d. Filter Media: **[Graded silica sand]<Insert media>**.
 - e. Filter Backwash Interval:
 - 1) **<Insert psig (kPa)>** pressure drop measured by differential pressure gauges.
 - 2) **<Insert number>** days measured by time clock.
 - f. Circulating Pump:

- 1) Capacity: <Insert gpm (L/s)>.
- 2) Total Dynamic Head: <Insert feet (kPa)>.
- 3) Speed: <Insert rpm>.
- 4) Inlet Size: <Insert NPS (DN)>.
- 5) Outlet Size: <Insert NPS (DN)>.

g. Pump Motor Size and Electrical Characteristics:

- 1) Horsepower: <Insert value>.
- 2) Volts: [120][208][240][277][480]<Insert value>.
- 3) Phase: [Single][Three].
- 4) Hertz: [60]<Insert value>.

h. Unit Electrical Characteristics:

- 1) Full-Load Amperes: <Insert value>.
- 2) Minimum Circuit Ampacity: <Insert value>.
- 3) Maximum Overcurrent Protection: <Insert amperage> A.

B. Filters - Sand Type, Multimedia:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Culligan International Company]
- b. [Diamond H2O]
- c. [Everfilt]
- d. [Hungerford & Terry, Inc]
- e. [LAKOS Filtration Solutions]
- f. [Marlo Incorporated]
- g. [Mer-Made Filter, Inc.]
- h. [Miami Filter, Inc.]
- i. [PEP Filters, Inc.]
- j. [Puroflux Corporation]
- k. [Water King]
- l. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Culligan International Company]
- b. [Diamond H2O]
- c. [Everfilt]
- d. [Hungerford & Terry, Inc]
- e. [LAKOS Filtration Solutions]
- f. [Marlo Incorporated]
- g. [Mer-Made Filter, Inc.]
- h. [Miami Filter, Inc.]
- i. [PEP Filters, Inc.]
- j. [Puroflux Corporation]
- k. [Water King]
- l. <Insert manufacturer's name>

3. Description: Factory-fabricated and -tested, [simplex][duplex][triplex], multimedia, sand-filter system of filter tank(s), media, piping, and controls for removing sediment particles from water.
 - a. Tank Construction:
 - 1) Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
 - 2) Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code, Section X, if indicated.
 - 3) Fabricate supports and base and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.
 - b. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - c. Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606.
 - d. FRP Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Type A, integral; **[Designation E, 125 psig (0.862 MPa)][or][Designation F, 150 psig (1.034 MPa)]** pressure category flanges of grade same as tank material in accordance with ASTM D5421.
 - e. Service Valve(s): Diaphragm type **[hydraulically][pneumatically]** operated.
 - f. Piping:
 - 1) **[Galvanized steel pipe, galvanized cast-iron fittings][Stainless steel pipe, stainless steel fittings]**, and flanged, grooved, or threaded joints.
 - 2) **ASTM B88, Type L (ASTM B88M, Type B)** copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
 - 3) Schedule 80 ABS or PVC pipe and fittings with solvent-cemented joints.
 - g. Safety Valves: Automatic air vent.
 - h. Controls for Simplex Tank System: Automatic, electric time clock for control of filter system flow and backwash cycles; factory wired for single, external electrical connection.
 - i. Controls for Duplex and Triplex Tank Systems: Automatic, electric time clock for control of filter system flow and backwash cycles; factory wired for single, external electrical connection. System operation is to be continuous with bypass piping and not more than one tank in backwash cycle at same time.
 - j. Support: Skid mounting.
4. Capacity and Characteristics:
 - a. Filtrate Design Concentrations:
 - 1) Chlorine: **<Insert ppm (mg/L)>**.
 - 2) Color: **<Insert nephelometric turbidity units>**.
 - 3) Iron: **<Insert ppm (mg/L)>**.
 - 4) Manganese: **<Insert ppm (mg/L)>**.
 - 5) Total Dissolved Solids: **<Insert ppm (mg/L)>**.
 - 6) Turbidity: **<Insert ppm (mg/L)>**.
 - 7) **<Insert characteristic>**: **<Insert value>**.
 - b. Filter Design:
 - 1) Continuous Flow: **<Insert gpm (L/s)>** at **<Insert psig (kPa)>** pressure drop.
 - 2) Peak Flow: **<Insert gpm (L/s)>** at **<Insert psig (kPa)>** pressure drop.
 - 3) Filtration Efficiency: **[98]<Insert number>** percent removal of suspended particles

[10][20][40]<Insert size> microns and larger from feedwater of listed filtrate design concentrations.

- 4) Backwash Flow: <Insert gpm (L/s)> at <Insert psig (kPa)> pressure drop.

c. Media Tanks:

- 1) Single with controls.
- 2) [Two][Three] with manifolded inlet, outlet, and drain piping and controls.

d. Each Media Tank:

- 1) Material: [Carbon steel with NSF 61 Annex lining material][FRP]<Insert material>.
- 2) Pressure Rating: <Insert psig (kPa)> minimum.
- 3) Distribution System: Factory-installed plastic.
- 4) Temperature Rating: <Insert deg F (deg C)> minimum.
- 5) Diameter: <Insert inches (mm)>.
- 6) Height: <Insert inches (mm)>.
- 7) Service Valve Size: <Insert NPS (DN)>.
- 8) Inlet and Outlet Size: <Insert NPS (DN)>.
- 9) Drain Size: <Insert NPS (DN)>.

e. Filter Media: [Graded silica sand]<Insert media>.

C. Filters - Greensand Type:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Diamond H2O]
 - b. [Hungerford & Terry, Inc]
 - c. [Marlo Incorporated]
 - d. [PEP Filters, Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Diamond H2O]
 - b. [Hungerford & Terry, Inc]
 - c. [Marlo Incorporated]
 - d. [PEP Filters, Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. <Insert manufacturer's name>
3. Description: Greensand-type filter system of piping, and controls for removing [iron][iron and manganese][manganese] from water.
 - a. Tank Construction:
 - 1) Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure

- Vessel Code, Section VIII, Division 1.
 - 2) Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code, Section X.
 - 3) Fabricate supports, base, and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.
 - b. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - c. Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606.
 - d. FRP Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Type A, integral; **[Designation E, 125 psig (0.862 MPa)]****[or]****[Designation F, 150 psig (1.034 MPa)]** pressure category flanges of grade same as tank material in accordance with ASTM D5421.
 - e. Service Valve(s): Diaphragm type **[hydraulically]****[pneumatically]** operated.
 - f. Piping:
 - 1) **[Galvanized steel pipe, galvanized cast-iron fittings]****[Stainless steel pipe, stainless steel fittings]**, and flanged, grooved, or threaded joints.
 - 2) **ASTM B88, Type L (ASTM B88M, Type B)** copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
 - 3) Schedule 80 ABS or PVC pipe and fittings with solvent-cemented joints.
 - g. Safety Valves: Automatic air vent.
 - h. Controls for Simplex Tank System: Automatic, electric time clock for control of filter system flow and backwash cycles; factory wired for single, external electrical connection.
 - i. Controls for Tank System: **[Duplex]****[Triplex]****<Insert type>**. Automatic, electric time clock controls filter system flow and backwash cycles; factory wired for single, external electrical connection. System operation is to be continuous with bypass piping and not more than one tank in backwash cycle at same time.
 - j. Support: Skid mounting.
4. Capacity and Characteristics:
 - a. Filtrate Design Concentrations:
 - 1) Iron: **<Insert ppm (mg/L)>**.
 - 2) Manganese: **<Insert ppm (mg/L)>**.
 - 3) **<Insert characteristic>**: **<Insert value>**.
 - b. Filter Design:
 - 1) Continuous Flow: **<Insert gpm (L/s)>** at **<Insert psig (kPa)>** pressure drop.
 - 2) Peak Flow: **<Insert gpm (L/s)>** at **<Insert psig (kPa)>** pressure drop.
 - 3) Filtration Efficiency: **[98]****<Insert number>** percent removal of suspended particles **[10]****[20]****[40]****<Insert size>** microns and larger from feedwater of listed filtrate design concentrations.
 - 4) Backwash Flow: **<Insert gpm (L/s)>** at **<Insert psig (kPa)>** pressure drop.
 - c. Media Tanks:
 - 1) Single with controls.
 - 2) **[Two]****[Three]** with manifolded inlet, outlet, and drain piping and controls.
 - d. Each Media Tank:

- 1) Material: [**Carbon steel with NSF 61 Annex lining material**][FRP]<Insert material>.
- 2) Pressure Rating: <Insert psig (kPa)> minimum.
- 3) Distribution System: Factory-installed plastic.
- 4) Temperature Rating: <Insert deg F (deg C)> minimum.
- 5) Diameter: <Insert inches (mm)>.
- 6) Height: <Insert inches (mm)>.
- 7) Service Valve Size: <Insert NPS (DN)>.
- 8) Inlet and Outlet Size: <Insert NPS (DN)>.
- 9) Drain Size: <Insert NPS (DN)>.

e. Filter Media: [**Graded silica sand**]<Insert media>.

2.7 SEPARATORS

A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [**LAKOS Filtration Solutions**]
2. [**PEP Filters, Inc.**]
3. [**Puroflux Corporation**]
4. [**Rosedale Products, Inc.**]
5. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [**LAKOS Filtration Solutions**]
2. [**PEP Filters, Inc.**]
3. [**Puroflux Corporation**]
4. [**Rosedale Products, Inc.**]
5. <Insert manufacturer's name>

C. Description:

1. Simplex separator housing with baffles and chambers for removing sediment particles from water by centrifugal action and gravity.
2. Factory-fabricated and -tested, simplex separator system of housing with baffles and chambers, strainer, circulating pump, piping, and controls for removing sediment particles from water by centrifugal action and gravity.

D. Housing: With manufacturer's proprietary system of baffles and chambers.

1. Construction:
 - a. Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
 - b. Fabricate supports, base, and attachment to separator housing with reinforcement strong enough to resist separator movement during a seismic event when separator base is anchored to building structure.
2. Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
3. Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.

4. Collection Chamber: Designed to hold separated particles.
 5. Outlet: Near top of unit.
 6. Purge: At bottom of collection chamber.
 7. Pipe Connections **NPS 2 (DN 50)** and Smaller: Threaded in accordance with ASME B1.20.1.
 8. Pipe Connections **NPS 2-1/2 (DN 65)** and Larger: ASME B16.1; steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606. Provide stainless steel flanges if tank is stainless steel.
- E. Strainer: Basket type.
1. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 2. Pipe Connections NPS 2-1/2 (DN 65) and Larger: Cast-iron, Class 125 flanges in accordance with ASME B16.1.
- F. Piping:
1. **[Galvanized steel pipe, galvanized cast-iron fittings][Stainless steel pipe, stainless steel fittings]**, and flanged, grooved, or threaded joints.
 2. **ASTM B88, Type L (ASTM B88M, Type B)** copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
- G. Safety Valves: Automatic and manual pressure relief.
- H. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
1. Pump Construction: Bronze fitted.
 - a. Casing: Radially split, cast iron.
 - b. Pressure Rating: **[125 psig (860 kPa)][150 psig (1035 kPa)]** minimum.
 - c. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
 - d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
 - e. Seal: Mechanical.
 2. Motor: General requirements for motors are specified in Section 220500 "Common Work Results for Plumbing."
- I. Controls: Automatic for control of circulating pump and separator purge; factory wired for single, external electrical connection.
1. Panel: NEMA 250, **[Type 4]<Insert type>** enclosure.
 2. Pump: Automatic and manual.
 3. Separator Purge: Automatic and manual.
- J. Support: Skid mounting.
- K. Capacity and Characteristics:
1. Filtrate Design Concentrations:
 - a. Sand: **<Insert ppm (mg/L)>**.
 - b. Silt: **<Insert ppm (mg/L)>**.
 - c. **<Insert characteristic>: <Insert value>**.
 2. Separator Design:

- a. Continuous Flow: **<Insert gpm (L/s)>** at **[5 psig (34.5 kPa)]<Insert value>** pressure drop.
- b. Peak Flow: **<Insert gpm (L/s)>**.
- c. Separator Efficiency: **[98]<Insert number>** percent removal of listed **[1.8]<Insert number>** minimum specific-gravity suspended particles **[5][10][20][45]<Insert size>** microns and larger from feedwater of listed filtrate design concentrations.

3. Housing:

- a. Material: **[Carbon][Stainless]** steel.
- b. Pressure Rating: **<Insert psig (kPa)>**.
- c. Diameter: **<Insert inches (mm)>**.
- d. Height: **<Insert inches (mm)>**.
- e. Inlet and Outlet Size: **<Insert NPS (DN)>**.
- f. Purge Size: **<Insert NPS (DN)>**.

4. Circulating Pump:

- a. Capacity: **<Insert gpm (L/s)>**.
- b. Total Dynamic Head: **<Insert feet (kPa)>**.
- c. Speed: **<Insert rpm>**.
- d. Inlet Size: **<Insert NPS (DN)>**.
- e. Outlet Size: **<Insert NPS (DN)>**.

5. Pump Motor Size and Electrical Characteristics:

- a. Horsepower: **<Insert value>**.
- b. Volts: **[120][208][240][277][480]<Insert value>**.
- c. Phase: **[Single][Three]**.
- d. Hertz: **[60]<Insert value>**.

6. Unit Electrical Characteristics:

- a. Full-Load Amperes: **<Insert value>**.
- b. Minimum Circuit Ampacity: **<Insert value>**.
- c. Maximum Overcurrent Protection: **<Insert amperage>** A.

2.8 SOURCE QUALITY CONTROL

- A. Before shipping, hydrostatically test **[carbon-type filters,][circulating sand-type filters,][multimedia sand-type filters,][greensand-type filters,][and][separators]** to minimum of one and one-half times pressure rating.
- B. Prepare test reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of **[filters][and][separators]**.

- B. Examine roughing-in for piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls and floors for suitable conditions where **[filters][and][separators]** will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT MOUNTING

- A. Equipment Mounting: Install **[filters, except wall-mounted cartridge-type filters,][and][separators]** on concrete bases. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.3 INSTALLATION OF BAG-TYPE FILTER

- A. Install bag-type filters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- B. Equipment Mounting: Install filters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
- C. Install filter media bags.
- D. Install seismic restraints for bag-type filter housings and anchor to building structure.

3.4 INSTALLATION OF CARTRIDGE-TYPE FILTER

- A. Install cartridge-type filters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- B. Equipment Mounting: Install freestanding cartridge-type filters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Exception: Omit concrete bases if installation directly on floor is indicated.
- C. Attach wall brackets for off-floor, wall-mounted, cartridge filter to vertical surface. Attach housing(s), and base if any, to wall bracket.
- D. Install housings for off-floor, in-line, cartridge filters in piping.
- E. Install filter elements in cartridges.

- F. Install seismic restraints for freestanding cartridge-filter housings and anchor to building structure.

3.5 INSTALLATION OF CARBON-TYPE FILTER

- A. Install carbon-type filters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- B. Equipment Mounting: Install carbon-type filters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
- C. Prepare carbon-filter tank distribution system and underbed, if any, for filter media, and place specified media into tanks.
- D. Install seismic restraints for carbon-filter housings and anchor to building structure.

3.6 INSTALLATION OF SAND-TYPE FILTER

- A. Install sand-type filters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- B. Equipment Mounting: Install sand-filter tanks on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
- C. Prepare sand-filter tank distribution system and underbed for filter media, and place specified sand and other media into tanks.
- D. Install seismic restraints for sand-filter tanks and accessories and anchor to building structure.

3.7 INSTALLATION OF SEPARATOR

- A. Install separators level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- B. Equipment Mounting: Install separators on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
- C. Install seismic restraints for separators and accessories and anchor to building structure.

3.8 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Make piping connections between water filtration equipment and dissimilar-metal water piping with dielectric fittings. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic

Water Piping."

- D. Install shutoff valves on feedwater-inlet and filtrate-outlet piping of each water filtration equipment **[filter][and][separator][and on inlet and outlet headers]**.
 - 1. Comply with requirements for metal general-duty valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
 - 2. Comply with requirements for plastic valves specified in Section 221116 "Domestic Water Piping."
 - 3. Exception, Shutoff Valve Installation: Water filtration equipment with factory-installed shutoff valves at locations indicated.
- E. Install pressure gauges on feedwater-inlet and filtrate-outlet piping of each water filtration equipment **[filter][and][separator]**. Comply with requirements for pressure gauges specified in Section 220500 "Common Work Results for Plumbing."
 - 1. Exception, Pressure Gauge Installation:
 - a. Water filtration equipment with factory-installed pressure gauges.
 - b. Cartridge-type water filters.
- F. Install valved bypass water piping around each water filtration equipment **[filter][and][separator]**.
 - 1. Comply with requirements for metal general-duty valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
 - 2. Comply with requirements for plastic valves specified in Section 221116 "Domestic Water Piping."
 - 3. Comply with requirements for water piping specified in Section 221116 "Domestic Water Piping."
 - 4. Exception, Valved Bypass Water Piping Installation:
 - a. Bag-type water filtration equipment.
 - b. Cartridge-type water filtration equipment.
- G. Install drains as indirect wastes to spill into open drains or over floor drains.

3.9 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.10 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service for **[circulating sand-type filters,][multimedia sand-type filters,][greensand-type filters,][and][separators]**.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. **<Insert additional startup steps if any>**.
- B. Sample **[filter][and][separator]** filtrate after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics.



3.11 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service, Including Testing: Engage a factory-authorized service representative to **[support][supervise]** field tests and inspections.
- C. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Domestic water filtration equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.12 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain **[circulating sand-type filters,][multimedia sand-type filters,][greensand-type filters,][and][separators]**.

END OF SECTION 22 32 00 00



Task	Specification	Specification Description
22 32 16 00	22 32 00 00	Domestic Water Filtration Equipment



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 33 00 00 - ELECTRIC DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Domestic-water booster heater, electric - commercial type.
2. Domestic-water heater, electric - commercial, storage type.
3. Domestic-water heater, electric - commercial, light-duty type.
4. Domestic-water heater, electric - commercial, hybrid heat pump type.
5. Domestic-water heater, electric - residential, small-capacity type.
6. Domestic-water heater, electric - residential, collector-to-tank, solar type.
7. Domestic-water heater, electric - residential, collector-to-tank-coil, solar type.
8. Domestic-water heater, electric - residential, storage type.
9. Domestic-water heater, electric - residential, tabletop type.
10. Domestic water heater, electric - residential, hybrid heat pump type.
11. Domestic-water heater, electric - flow-control, tankless type.
12. Domestic-water heater, electric - thermostat-control, tankless type.
13. Domestic-water heater accessories.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

1. Product Data: For energy efficiency.
2. Water Heaters: Product Data for water heater compliance with ASHRAE's "Advanced Energy Design Guides."

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room drawing or BIM model, drawn to scale, on which the items described in this Section are shown and coordinated with all building trades.

B. Seismic Qualification Certificates: For commercial domestic-water heaters, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and

- describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- C. Product Certificates: For each type of **[commercial][residential][and][tankless]**, electric, domestic-water heater.
- D. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
- E. Source quality control reports.
- F. Field quality control reports.
- G. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For electric, domestic-water heaters.

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 2. Warranty Periods: From date of Substantial Completion.
 - a. Commercial, Electric, Domestic-Water Heaters:
 - 1) Tank: **[Three][Five]<Insert number>** years.
 - 2) Controls and Other Components: **[Three][Five]<Insert number>** years.
 - b. Residential, Electric, Storage, Domestic-Water Heaters:
 - 1) Tank: **[Five][Six][10]<Insert number>** years.
 - 2) Controls and Other Components: **[Two][Three]<Insert number>** years.
 - c. Electric, Tankless, Domestic-Water Heaters: **[One][Two][Five]<Insert number>** year(s).
 - d. Expansion Tanks: **[Five]<Insert number>** years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electric domestic water heater equipment intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act, with requirements of authorities having jurisdiction, and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
- C. Seismic Performance: Electric, domestic-water heaters to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- F. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

2.2 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

- A. Domestic-Water Booster Heater, Electric - Commercial Type:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[Coates Heater Company, Inc.]**
 - c. **[Electric Heater Company (The)]**
 - d. **[Hatco Corporation]**
 - e. **[HESco Industries, Inc]**
 - f. **[Lochinvar, LLC]**
 - g. **[Rheem Manufacturing Company]**
 - h. **[Ruud Water Heaters; a Rheem brand]**
 - i. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [A. O. Smith Corporation]
 - b. [Coates Heater Company, Inc.]
 - c. [Electric Heater Company (The)]
 - d. [Hatco Corporation]
 - e. [HESco Industries, Inc]
 - f. [Lochinvar, LLC]
 - g. [Rheem Manufacturing Company]
 - h. [Ruud Water Heaters; a Rheem brand]
 - i. <Insert manufacturer's name>
3. Source Limitations: Obtain domestic-water booster heaters, electric - commercial type from single source from single manufacturer.
 4. Standard: UL 1453.
 5. Tank Construction: [**Corrosion-resistant metal**][or][**steel**].
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **150 psig (1035 kPa)**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
 6. Factory-Installed Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - c. Insulation: Comply with ASHRAE/IES 90.1.
 - d. Jacket: Rectangular shaped, with stainless steel front panel, unless otherwise indicated.
 - e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
 - 1) Option: Booster heaters with total of 9 kW or less may have one, two, or three elements.
 - f. Temperature Control: Adjustable thermostat, to setting of at least **180 deg F (82 deg C)**.
 - g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
 - h. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valve. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.
 - i. Gauges: Combination temperature-and-pressure type or separate thermometer and pressure gauge.
 7. Special Requirements: NSF 5 construction with [**brackets for undercounter**][**legs for floor**] installation.
- B. Domestic-Water Heater, Electric - Commercial, Storage Type:
1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. [A. O. Smith Corporation]
 - b. [American Water Heaters]
 - c. [Bradford White Corporation]
 - d. [Cemline Corporation]

- e. **[Chronomite Laboratories, Inc; a division of Morris Group International]**
 - f. **[Electric Heater Company (The)]**
 - g. **[HESco Industries, Inc]**
 - h. **[Lochinvar, LLC]**
 - i. **[Precision Boilers]**
 - j. **[PVI; A WATTS Brand]**
 - k. **[Rheem Manufacturing Company]**
 - l. **[State Water Heaters]**
 - m. **[Vaughn Thermal Corporation]**
 - n. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[Cemline Corporation]**
 - e. **[Chronomite Laboratories, Inc; a division of Morris Group International]**
 - f. **[Electric Heater Company (The)]**
 - g. **[HESco Industries, Inc]**
 - h. **[Lochinvar, LLC]**
 - i. **[Precision Boilers]**
 - j. **[PVI; A WATTS Brand]**
 - k. **[Rheem Manufacturing Company]**
 - l. **[State Water Heaters]**
 - m. **[Vaughn Thermal Corporation]**
 - n. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters, electric - commercial, storage type from single source from single manufacturer.
4. Standard: UL 1453.
5. Tank Construction: **[Non-]ASME-code, steel [horizontal][vertical]** arrangement.
- a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges, and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 - b. Pressure Rating: **[150 psig (1035 kPa)]<Insert value>**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
6. Factory-Installed, Tank Appurtenances:
- a. Anode Rod: Replaceable magnesium.
 - b. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - c. Insulation: Comply with ASHRAE/IES 90.1.
 - d. Jacket: Steel with enameled finish or high-impact composite material.
 - e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
 - f. Temperature Control: Adjustable thermostat.

- g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
- h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

7. Special Requirements: NSF 5 construction.

C. Domestic-Water Heater, Electric - Commercial, Light-Duty Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[Electric Heater Company (The)]**
 - e. **[Heat Transfer Products, Inc]**
 - f. **[Lochinvar, LLC]**
 - g. **[Rheem Manufacturing Company]**
 - h. **[Ruud Water Heaters; a Rheem brand]**
 - i. **[State Water Heaters]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[Electric Heater Company (The)]**
 - e. **[Heat Transfer Products, Inc]**
 - f. **[Lochinvar, LLC]**
 - g. **[Rheem Manufacturing Company]**
 - h. **[Ruud Water Heaters; a Rheem brand]**
 - i. **[State Water Heaters]**
 - j. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters, electric - commercial, light-duty type from single source from single manufacturer.
4. Standard: UL 174.
5. Tank Construction: Steel, vertical arrangement.
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **150 psig (1035 kPa)**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
6. Factory-Installed, Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.

- c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with ASHRAE/IES 90.1.
 - e. Jacket: Steel with enameled finish or high-impact composite material.
 - f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - g. Heating Elements: Electric, screw-in immersion type.
 - h. Temperature Control: Adjustable thermostat.
 - i. Safety Control: High-temperature-limit cutoff device or system.
 - j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.
7. Special Requirements: NSF 5 construction with legs for off-floor installation.
- D. Domestic-Water Heater, Electric - Commercial, Hybrid Heat Pump Type:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[Hubbell Heaters; a Nudyne Company]**
 - c. **[Lochinvar, LLC]**
 - d. **[State Water Heaters]**
 - e. **[Vaughn Thermal Corporation]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[Hubbell Heaters; a Nudyne Company]**
 - c. **[Lochinvar, LLC]**
 - d. **[State Water Heaters]**
 - e. **[Vaughn Thermal Corporation]**
 - f. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain domestic-water heaters, electric - commercial hybrid heat pumps from single source from single manufacturer.
 4. Standards: **AHRI 1300 (AHRI 1301)**.
 5. ENERGY STAR certified.
 6. Tank Construction: **[Non-ASME-code][ASME-code]**, steel **[horizontal][vertical]** arrangement.
 - a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - b. Pressure Rating: **[150 psig (1035 kPa)]<Insert pressure>** working pressure, **[300 psig (2070 kPa)]<Insert pressure>** test pressure.
 - c. Interior Material/Finish: **[Glass-lined][or][Hydrastone cement-lined]<Insert tank inner material>** tank. Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - d. Jacket: High-impact composite.

7. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: **[Replaceable magnesium][None required]**.
 - b. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - c. Insulation: Minimum **[3-inch- (75-mm-)]<Insert dimension>** thick CFC-free polyurethane foam insulation.
 - d. Jacket: Steel with enameled finish or high-impact composite material.
 - e. Backup Heating Elements: Electric, dual screw-in or bolt-on immersion type.
 - f. Temperature Control: Adjustable thermostat.
 - g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
 - h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

8. Heat Pump Module:
 - a. Air-to-air heat pump module including exhaust air outlet, intake air inlet, intake air filter, intake air fan, heat transfer coil, and condensate drain.
 - b. Factory mounted on top of water storage tank.
 - c. Heat pump operation down to minimum **[37 deg F (2.8 deg C)]<Insert minimum temperature>** ambient.
 - d. Ducting kit.
 - e. Washable inlet air filter.
 - f. Refrigerant: **[R-134a][R-426A]<Insert refrigerant>**.

9. Controls:
 - a. LCD display and local control panel, including display and control of the following:
 - 1) Water temperature setpoint.
 - 2) Water temperature setpoint up and down buttons.
 - 3) Degree F/Degree C toggle button.
 - 4) Operating mode selector buttons.
 - 5) Operating mode operation buttons.
 - 6) WiFi button.
 - 7) Bluetooth button.
 - 8) Alert indicator.
 - 9) Fault condition display code.
 - 10) "Control locked" indicator.
 - 11) **<Insert display features>**.
 - b. Digital, "Smart" Connectivity: Via **[Bluetooth app][and][WiFi]**.
 - c. Leak-Detection Sensor: Digital, "smart" sensor provides automatic water shutoff upon actuation.
 - d. Operating Modes:
 - 1) Hot Water-Plus Mode: Customizable amount of daily hot water.
 - 2) Hybrid (Default) Mode: Amount of hot water delivered is balanced with energy-saving performance. Heat pump switches to electric resistance heater mode only when required to meet high demand.
 - 3) Heat Pump Mode: Maximizes energy efficiency.
 - 4) Guest Mode: Provides maximum hot water for up to seven days' duration.
 - 5) Electric Mode: Provide hot water using only the electric backup heating elements.
 - 6) Vacation Mode: Prevents the heater from heating regardless of designated mode.

- Unit is to resume previous mode of operation after the vacation mode period ends.
- 7) **<Insert special operating mode>.**

10. Special Requirements: NSF 5 construction.

E. Capacity and Characteristics:

1. Capacity: **<Insert gal. (L)>.**
2. Recovery: **<Insert gph (L/s)>** at **[40 deg F (22 deg C)][50 deg F (28 deg C)][100 deg F (56 deg C)]<Insert temperature>** temperature rise.
3. Temperature Setting: **[125 deg F (52 deg C)][140 deg F (60 deg C)][180 deg F (82 deg C)]<Insert temperature>.**
4. Power Demand: **<Insert kilowatts>.**
5. Heating Elements:
 - a. Number of Elements: **[Two]<Insert number>.**
 - b. Kilowatts, Each Element: **<Insert kilowatts>.**
 - c. Number of Stages: **[One]<Insert number>.**
6. Electrical Characteristics:
 - a. Volts: **[120][240][277][480]<Insert value> V.**
 - b. Phases: **[Single][Three].**
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value> A.**
 - e. Minimum Circuit Ampacity: **<Insert value> A.**
 - f. Maximum Overcurrent Protection: **<Insert value> A.**

2.3 RESIDENTIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Domestic-Water Heater, Electric - Residential, Small-Capacity Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bosch Thermotechnology Corp.]**
 - d. **[Bradford White Corporation]**
 - e. **[Eemax, Inc.; a Rheem brand]**
 - f. **[Electric Heater Company (The)]**
 - g. **[GSW Water Heaters]**
 - h. **[Lochinvar, LLC]**
 - i. **[Stiebel Eltron, Inc]**
 - j. **[WaiWela]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**

- c. **[Bosch Thermotechnology Corp.]**
 - d. **[Bradford White Corporation]**
 - e. **[Eemax, Inc.; a Rheem brand]**
 - f. **[Electric Heater Company (The)]**
 - g. **[GSW Water Heaters]**
 - h. **[Lochinvar, LLC]**
 - i. **[Stiebel Eltron, Inc]**
 - j. **[WaiWela]**
 - k. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters, electric - residential, small-capacity type from single source from single manufacturer.
4. Standard: UL 174.
5. Tank Construction: Corrosion-resistant metal **[or steel with corrosion-resistant coating]**.
- a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **150 psig (1035 kPa)**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
6. Factory-Installed, Storage-Tank Appurtenances:
- a. Drain Valve: Corrosion-resistant metal with hose-end connection if tank has drain outlet. Provide hose-end drain valve in piping for domestic-water heaters without drain outlet. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."
 - b. Insulation: Comply with **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
 - c. Jacket: Steel with enameled finish or high-impact composite material.
 - d. Heating Element: One; electric, screw-in immersion type.
 - e. Temperature Control: Adjustable thermostat.
 - f. Safety Control: High-temperature-limit cutoff device or system.
 - g. Power Supply Cord: **24 to 72 inches (610 to 1830 mm)** with plug.
 - h. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.
- B. Domestic-Water Heater, Electric - Residential, Collector-to-Tank, Solar Type:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Alternate Energy Technologies, LLC]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[Lochinvar, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Alternate Energy Technologies, LLC]**

- b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[Lochinvar, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain domestic-water heaters, electric - residential, collector-to-tank, solar type from single source from single manufacturer.
 4. Standard: UL 174 with piping and electrical connections for UL 1279 solar collector system.
 5. Tank Construction: Steel.
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **150 psig (1035 kPa)**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
 6. Factory-Installed, Storage-Tank Appurtenances:
 - a. Sensor electrical connections and tank stud for sensor.
 - b. Anode Rod: Replaceable magnesium.
 - c. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - d. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - e. Insulation: Comply with **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
 - f. Jacket: Steel with enameled finish.
 - g. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - h. Heating Element: Electric, screw-in immersion type.
 - i. Temperature Control: Adjustable thermostat.
 - j. Safety Control: High-temperature-limit cutoff device or system.
 - k. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.
- C. Domestic-Water Heater, Electric - Residential, Collector-to-Tank-Coil, Solar Type:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Alternate Energy Technologies, LLC]**
 - b. **[Electric Heater Company (The)]**
 - c. **[Vaughn Thermal Corporation]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alternate Energy Technologies, LLC]**
 - b. **[Electric Heater Company (The)]**
 - c. **[Vaughn Thermal Corporation]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain domestic-water heaters, electric - residential, collector-to-tank-coil, solar type from single source from single manufacturer.
 4. Standard: UL 174 with integral coil-type heat exchanger.

5. Tank Construction: Steel.
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **150 psig (1035 kPa)**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
6. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
 - e. Jacket: Steel with enameled finish or high-impact composite material.
 - f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - g. Heat Exchanger: Corrosion-resistant-metal immersion coil.
 - h. Heating Element: Electric, screw-in immersion type.
 - i. Temperature Control: Adjustable thermostat.
 - j. Safety Control: High-temperature-limit cutoff device or system.
 - k. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

D. Domestic-Water Heater, Electric - Residential, Storage Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[GSW Water Heaters]**
 - e. **[Heat Transfer Products, Inc]**
 - f. **[Lochinvar, LLC]**
 - g. **[State Water Heaters]**
 - h. **[Vaughn Thermal Corporation]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[GSW Water Heaters]**
 - e. **[Heat Transfer Products, Inc]**
 - f. **[Lochinvar, LLC]**
 - g. **[State Water Heaters]**
 - h. **[Vaughn Thermal Corporation]**
 - i. **<Insert manufacturer's name>**

3. Source Limitations: Obtain domestic-water heaters, electric - residential, storage type from single source from single manufacturer.
4. Standard: UL 174.
5. Tank Construction: Steel.
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **150 psig (1035 kPa)**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material intoappings.
6. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
 - e. Jacket: Steel, cylindrical, with enameled finish or high-impact composite material.
 - f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - g. Heating Elements: Electric, screw-in immersion type.
 - h. Temperature Control: Adjustable thermostat.
 - i. Safety Control: High-temperature-limit cutoff device or system.
 - j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

E. Domestic-Water Heaters, Electric - Residential, Tabletop Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[State Water Heaters]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[State Water Heaters]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters, electric - residential, tabletop type from single source from single manufacturer.
4. Standard: UL 174.
5. Tank Construction: Steel.
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **150 psig (1035 kPa)**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material intoappings.

6. Factory-Installed, Storage-Tank Appurtenances:

- a. Anode Rod: Replaceable magnesium.
- b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
- c. Drain Valve: Corrosion-resistant metal with hose-end connection.
- d. Insulation: Comply with **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
- e. Jacket: Steel, rectangular, with flat-top work surface, raised back, and enameled finish.
- f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
- g. Heating Elements: Electric, screw-in immersion type.
- h. Temperature Control: Adjustable thermostat.
- i. Safety Control: High-temperature-limit cutoff device or system.
- j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

F. Domestic-Water Heater, Electric - Residential, Hybrid Heat Pump Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[GSW Water Heaters]**
 - e. **[Heat Transfer Products, Inc]**
 - f. **[Lochinvar, LLC]**
 - g. **[State Water Heaters]**
 - h. **[Vaughn Thermal Corporation]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[GSW Water Heaters]**
 - e. **[Heat Transfer Products, Inc]**
 - f. **[Lochinvar, LLC]**
 - g. **[State Water Heaters]**
 - h. **[Vaughn Thermal Corporation]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters, electric - residential, hybrid heat pump type from single source from single manufacturer.
4. Standard: UL 60335-2-40.
5. ENERGY STAR certified.
6. Tank Construction: Non-ASME-code, steel **[horizontal][vertical]** arrangement.
 - a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.

- 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - b. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> working pressure, [300 psig (2070 kPa)]<Insert pressure> test pressure.
 - c. Interior Material/Finish: [Glass-lined][or][Hydrastone cement-lined]<Insert tank inner material> tank. Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - d. Jacket: High-impact composite.
7. Factory-Installed, Storage-Tank Appurtenances:
- a. Anode Rod: [Replaceable magnesium][None required].
 - b. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - c. Insulation: Minimum [3-inch- (75-mm-)][2-inch- (50-mm-)]<Insert dimension> thick CFC-free polyurethane foam insulation.
 - d. Jacket: Steel with enameled finish or high-impact composite material.
 - e. Backup Heating Elements: Electric, dual screw-in or bolt-on immersion type.
 - f. Temperature Control: Adjustable thermostat.
 - g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
 - h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
8. Heat Pump Module:
- a. Air-to-air heat pump module including exhaust air outlet, intake air inlet, intake air filter, intake air fan, heat transfer coil and condensate drain.
 - b. Factory-mounted on top of water storage tank.
 - c. Heat pump operation down to minimum [37 deg F (2.8 deg C)]<Insert minimum temperature> ambient.
 - d. Ducting kit.
 - e. Washable inlet air filter.
 - f. Refrigerant: [R-134a][R-426A]<Insert refrigerant>.
9. Controls:
- a. LCD display and local control panel, including display and control of the following:
 - 1) Water temperature setpoint.
 - 2) Water temperature setpoint up and down buttons.
 - 3) Degree F/Degree C toggle button.
 - 4) Operating mode selector buttons.
 - 5) Operating mode operation buttons.
 - 6) WiFi button.
 - 7) Bluetooth button.
 - 8) Alert indicator.
 - 9) Fault condition display code.
 - 10) "Control locked" indicator.
 - 11) <Insert display features>.
 - b. Digital, "Smart" Connectivity: Via [Bluetooth app][and][WiFi].
 - c. Leak-Detection Sensor: Digital, "smart" sensor provides automatic water shutoff upon actuation.
 - d. Operating Modes:

- 1) Hot Water-Plus Mode: Customizable amount of daily hot water.
- 2) Hybrid (Default) Mode: Amount of hot water delivered is balanced with energy-saving performance. Heat pump switches to electric resistance heater mode only when required to meet high demand.
- 3) Heat Pump Mode: Maximizes energy efficiency.
- 4) Guest Mode: Provides maximum hot water for up to seven days' duration.
- 5) Electric Mode: Provide hot water using only the electric backup heating elements.
- 6) Vacation Mode: Prevents the heater from heating regardless of designated mode. Unit is to resume previous mode of operation after the vacation mode period ends.
- 7) **<Insert special operating mode>.**

G. Capacity and Characteristics:

1. Capacity: **<Insert gal. (L)>.**
2. Recovery: **<Insert gph (L/s)>** at **[100 deg F (56 deg C)]<Insert temperature>** temperature rise.
3. Temperature Setting: **[125 deg F (52 deg C)]<Insert temperature>.**
4. Power Demand: **<Insert kilowatts>.**
5. Heating Elements: **<Insert kilowatts>.**
6. Electrical Characteristics:
 - a. Volts: **[120][240]<Insert value> V.**
 - b. Phases: **[Single][Three].**
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value> A.**
 - e. Minimum Circuit Ampacity: **<Insert value> A.**
 - f. Maximum Overcurrent Protection: **<Insert value> A.**

2.4 ELECTRIC, TANKLESS, DOMESTIC-WATER HEATERS

A. Domestic-Water Heater, Electric - Flow-Control, Tankless Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Bosch Thermotechnology Corp.]**
 - b. **[Bradley Corporation]**
 - c. **[Chronomite Laboratories, Inc; a division of Morris Group International]**
 - d. **[Eemax, Inc.; a Rheem brand]**
 - e. **[Stiebel Eltron, Inc]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bosch Thermotechnology Corp.]**
 - b. **[Bradley Corporation]**
 - c. **[Chronomite Laboratories, Inc; a division of Morris Group International]**
 - d. **[Eemax, Inc.; a Rheem brand]**
 - e. **[Stiebel Eltron, Inc]**
 - f. **<Insert manufacturer's name>**

3. Source Limitations: Obtain domestic-water heaters, electric - flow-control, tankless type from single source from single manufacturer.
4. Standard: UL 499 for electric, tankless, (domestic-water-heater) heating appliance.
5. Construction: Copper piping or tubing complying with NSF 61 and NSF 372 barrier materials for potable water, without storage capacity.
 - a. Connections: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **[150 psig (1035 kPa)]<Insert value>**.
 - c. Heating Element: Resistance heating system.
 - d. Temperature Control: Flow-control fitting.
 - e. Safety Control: High-temperature-limit cutoff device or system.
 - f. Jacket: Aluminum or steel with enameled finish or plastic.
6. Support: Bracket for wall mounting.
7. Capacity and Characteristics:
 - a. Flow Rate: **<Insert gpm (L/s)>**.
 - b. Maximum Temperature Setting: **<Insert temperature>**.
 - c. Power Demand: **<Insert kilowatts>**.
 - d. Electrical Characteristics:
 - 1) Volts: **[120][240][277][480]<Insert value> V**.
 - 2) Phases: **[Single][Three]**.
 - 3) Hertz: 60 Hz.
 - 4) Full-Load Amperes: **<Insert value> A**.
 - 5) Minimum Circuit Ampacity: **<Insert value> A**.
 - 6) Maximum Overcurrent Protection: **<Insert value> A**.

B. Domestic-Water Heater, Electric - Thermostat-Control, Tankless Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bosch Thermotechnology Corp.]**
 - b. **[Bradley Corporation]**
 - c. **[Chronomite Laboratories, Inc; a division of Morris Group International]**
 - d. **[Eemax, Inc.; a Rheem brand]**
 - e. **[Niagara Industries, Inc.]**
 - f. **[Stiebel Eltron, Inc]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bosch Thermotechnology Corp.]**
 - b. **[Bradley Corporation]**
 - c. **[Chronomite Laboratories, Inc; a division of Morris Group International]**
 - d. **[Eemax, Inc.; a Rheem brand]**
 - e. **[Niagara Industries, Inc.]**
 - f. **[Stiebel Eltron, Inc]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters, electric - thermostat-control, tankless type

- from single source from single manufacturer.
4. Standard: UL 499 for electric, tankless, (domestic-water-heater) heating appliance.
 5. Construction: Copper piping or tubing complying with NSF 61 and NSF 372 barrier materials for potable water, without storage capacity.
 - a. Connections: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **[150 psig (1035 kPa)]<Insert value>**.
 - c. Heating Element: Resistance heating system.
 - d. Temperature Control: Thermostat.
 - e. Safety Control: High-temperature-limit cutoff device or system.
 - f. Jacket: Aluminum or steel with enameled finish or plastic.
 6. Support: Bracket for wall mounting.
 7. Capacity and Characteristics:
 - a. Flow Rate: **<Insert gpm (L/s)>** at **[100 deg F (56 deg C)]<Insert temperature>** temperature rise.
 - b. Temperature Setting: **[125 deg F (52 deg C)][140 deg F (60 deg C)]<Insert temperature>**.
 - c. Power Demand: **<Insert kilowatts>**.
 - d. Electrical Characteristics:
 - 1) Volts: **[120][240][277][480]<Insert value>** V.
 - 2) Phases: **[Single][Three]**.
 - 3) Hertz: 60 Hz.
 - 4) Full-Load Amperes: **<Insert value>** A.
 - 5) Minimum Circuit Ampacity: **<Insert value>** A.
 - 6) Maximum Overcurrent Protection: **<Insert value>** A.

2.5 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[AMTROL, Inc.]**
 - c. **[Flexcon Industries]**
 - d. **[Honeywell International Inc.]**
 - e. **[Pentair Aurora; Pentair Pump Group]**
 - f. **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - g. **[State Water Heaters]**
 - h. **[Taco Comfort Solutions]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[AMTROL, Inc.]**

- c. **[Flexcon Industries]**
 - d. **[Honeywell International Inc.]**
 - e. **[Pentair Aurora; Pentair Pump Group]**
 - f. **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - g. **[State Water Heaters]**
 - h. **[Taco Comfort Solutions]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water expansion tanks from single source from single manufacturer.
 4. Description: Steel pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
 5. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.
 6. Capacity and Characteristics:
 - a. Working-Pressure Rating: **[100 psig (690 kPa)][150 psig (1035 kPa)]<Insert value>**.
 - b. Capacity Acceptable: **[2 gal. (7.6 L)][4 gal. (15.1 L)][7 gal. (26.5 L)][10 gal. (37.9 L)]<Insert value> minimum.**
 - c. Air Precharge Pressure: **<Insert system pressure>**.
- B. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than **NPS 3/4 (DN 20)** with ASME B1.20.1 pipe threads.
- C. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
- D. Heat-Trap Fittings: **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
- E. Manifold Kits: Domestic-water-heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball-, butterfly-, or gate-type shutoff valves to isolate each domestic-water heater and **[calibrated][memory-stop]** balancing valves to provide balanced flow through each domestic-water heater.
1. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
 2. Comply with requirements for balancing valves specified in Section 221119 "Domestic Water Piping Specialties."
- F. Pressure-Reducing Valves: ASSE 1003 for water. Set at **25-psig- (172.5-kPa-)** maximum outlet pressure unless otherwise indicated.
- G. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.
- H. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than working-pressure rating of domestic-water heater.

- I. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.
- J. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.
- K. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater a minimum of **[18 inches (457 mm)]**<Insert dimension> above the floor.
- L. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.6 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, in accordance with ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test[**commercial**] domestic-water heaters to minimum of one and one-half times pressure rating before shipment.
- C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF ELECTRIC, DOMESTIC-WATER HEATERS

- A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
 - 2. Maintain manufacturer's recommended clearances.
 - 3. Arrange units so controls and devices that require servicing are accessible.
 - 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
 - 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 7. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 8. Anchor domestic-water heaters to substrate.
- B. Residential, Electric, Domestic-Water Heater Mounting: Install residential, electric, domestic-water heaters **[on floor][on water-heater stand on floor][on domestic-water heater mounting bracket]**.
 - 1. Maintain manufacturer's recommended clearances.
 - 2. Arrange units so controls and devices that require servicing are accessible.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.
 5. Anchor domestic-water heaters to substrate.
- C. Electric, Tankless, Domestic-Water Heater Mounting: Install electric, tankless, domestic-water heaters[**at least 18 inches (457 mm) above floor**] on wall bracket.
1. Maintain manufacturer's recommended clearances.
 2. Arrange units so controls and devices that require servicing are accessible.
 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
 5. Anchor domestic-water heaters to substrate.
- D. Install electric, domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- E. Install commercial, electric, domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in [**Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."**][**Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."**]
- F. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-water heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- G. Install[**combination temperature-and-**] pressure relief valves in water piping for electric, domestic-water heaters without storage. Extend domestic-water heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- H. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."
- I. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."
- J. Install thermometers on inlet and outlet piping of residential, solar, electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."
- K. Assemble and install inlet and outlet piping manifold kits for multiple electric, domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each electric, domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each electric, domestic-water heater outlet. Comply with requirements for valves specified in Section 220523 "General-Duty Valves for Plumbing Piping" and comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."
- L. Install pressure-reducing valve with integral bypass relief valve in electric, domestic-water booster-

heater inlet piping and water hammer arrester in booster-heater outlet piping. Set pressure-reducing valve for outlet pressure of [25 psig (172 kPa)]<Insert value>. Comply with requirements for pressure-reducing valves and water hammer arresters specified in Section 221119 "Domestic Water Piping Specialties."

- M. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.
- N. Fill electric, domestic-water heaters with water.
- O. Charge domestic-water expansion tanks with air to required system pressure.
- P. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water to contain less than 0.25 percent of lead by weight.

3.2 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: [Owner will engage][Engage] a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[with the assistance of a factory-authorized service representative].
- D. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain **[commercial][and][tankless]**, electric, domestic-water heaters. Training to be a minimum of **[one][two]<Insert duration>** hour(s).

END OF SECTION 22 33 00 00

THIS PAGE INTENTIONALLY LEFT BLANK



Task	Specification	Specification Description
22 33 30 16	22 33 00 00	Electric Domestic-Water Heaters
22 33 30 16	22 34 00 00	Fuel-Fired, Domestic-Water Heaters
22 33 33 00	22 33 00 00	Electric Domestic-Water Heaters



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 34 00 00 - FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Commercial, atmospheric, gas-fired, storage, domestic-water heaters.
2. Commercial, power-burner, gas-fired, storage, domestic-water heaters.
3. Commercial, power-vent, gas-fired, storage, domestic-water heaters.
4. Commercial, direct-vent, gas-fired, storage, domestic-water heater.
5. Commercial, gas-fired, high-efficiency, storage, domestic-water heaters.
6. Commercial, coil-type, finned-tube, gas-fired, domestic-water heaters.
7. Commercial, grid-type, finned-tube, gas-fired, domestic-water heaters.
8. Gas-fired, tankless, domestic-water heaters.
9. Residential, atmospheric, gas-fired, storage, domestic-water heaters.
10. Residential, direct-vent, gas-fired, storage, domestic-water heaters.
11. Residential, power-vent, gas-fired, storage, domestic-water heaters.
12. Commercial, oil-fired, storage, domestic-water heaters.
13. Commercial, large-volume, oil-fired, domestic-water heaters.
14. Residential, oil-fired, storage, domestic-water heaters.
15. Commercial, gas- and oil-fired, domestic-water heaters.
16. Domestic-water heater accessories.

1.2 ACTION SUBMITTALS

- ##### A. Product Data: For each type of product. [**Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.**]
- ##### B. Sustainable Design Submittals:
1. Product Data: For energy efficiency.
 2. Water Heaters: Product Data for water heater compliance with ASHRAE's "Advanced Energy Design Guides."
- ##### C. Shop Drawings:
1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- ##### A. Coordination Drawings: Equipment room drawing or BIM model, drawn to scale, on which the items described in this Section are shown and coordinated with all building trades.
- ##### B. Seismic Qualification Data: Certificates, for fuel-fired, domestic-water heaters, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- C. Product Certificates: For each type of **[commercial, gas-fired,][gas-fired, tankless,][residential, gas-fired,][commercial, oil-fired,][residential, oil-fired,][and][commercial, gas- and oil-fired,]** domestic-water heater.
- D. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
- E. Source quality-control reports.
- F. Field quality-control reports.
- G. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-fired, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
 - a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
2. Warranty Periods: From date of Substantial Completion.
 - a. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: **[Three][Five]<Insert number>** years.
 - 2) Controls and Other Components: **[One][Two]<Insert number>** year(s).
 - b. Commercial, Finned-Tube, Gas-Fired, Domestic-Water Heaters:
 - 1) Heat Exchanger: **[Three][Five]<Insert number>** years.
 - 2) Controls and Other Components: **[One][Two]<Insert number>** year(s).
 - 3) Separate Hot-Water Storage Tanks: **[Three][Five]<Insert number>** years.

- c. Gas-Fired, Tankless, Domestic-Water Heaters:
 - 1) Heat Exchanger: **[Five]<Insert number>** years.
 - 2) Controls and Other Components: **[Three]<Insert number>** years.
- d. Residential, Gas-Fired, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: **[Five][Six]<Insert number>** years.
 - 2) Controls and Other Components: **[Two][Three]<Insert number>** years.
- e. Commercial, Oil-Fired, Domestic-Water Heaters:
 - 1) Storage Tank: **[Three][Five]<Insert number>** years.
 - 2) Burner: **[One][Two]<Insert number>** year(s).
 - 3) Controls and Other Components: **[One][Two][Three]<Insert number>** year(s).
- f. Residential, Oil-Fired, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: **[Five][Six]<Insert number>** years.
 - 2) Burner: **[One][Two]<Insert number>** year(s).
 - 3) Controls and Other Components: **[Two][Three]<Insert number>** years.
- g. Commercial, Gas- and Oil-Fired, Domestic-Water Heaters:
 - 1) Storage Tank: **[Three][Five]<Insert number>** years.
 - 2) Burner: **[One][Two]<Insert number>** year(s).
 - 3) Controls and Other Components: **[Two][Three]<Insert number>** years.
- h. Expansion Tanks: **[Five]<Insert number>** years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
- B. Seismic Performance: Commercial domestic-water heaters shall withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- C. ASHRAE/IES Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IES 90.1.
 - 1. Comply with efficiency requirements in ASHRAE 189.1, which supersede requirements in ASHRAE/IESNA 90.1.

D. ASME Compliance:

1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

E. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.**2.2 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS****A. Commercial, Atmospheric, Gas-Fired, Storage, Domestic-Water Heaters:**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bock Water Heaters, Inc]**
 - d. **[Bradford White Corporation]**
 - e. **[HESco Industries, Inc]**
 - f. **[IBC Technologies; a Rheem brand]**
 - g. **[Lochinvar, LLC]**
 - h. **[PVI; A WATTS Brand]**
 - i. **[Raypak; a Rheem brand]**
 - j. **[Rheem Manufacturing Company]**
 - k. **[Ruud Water Heaters; a Rheem brand]**
 - l. **[State Industries]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bock Water Heaters, Inc]**
 - d. **[Bradford White Corporation]**
 - e. **[HESco Industries, Inc]**
 - f. **[IBC Technologies; a Rheem brand]**
 - g. **[Lochinvar, LLC]**
 - h. **[PVI; A WATTS Brand]**
 - i. **[Raypak; a Rheem brand]**
 - j. **[Rheem Manufacturing Company]**
 - k. **[Ruud Water Heaters; a Rheem brand]**
 - l. **[State Industries]**
 - m. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
4. Standard: ANSI Z21.10.3/CSA 4.3.

5. Storage-Tank Construction: **[Non-]**ASME-code steel with **[150-psig (1035-kPa)]**<Insert value> working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 - b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Lining: **[Cement][Glass][Nickel plate][Phenolic coating][Sheet copper]**<Insert material> complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
6. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
 - e. Jacket: Steel with enameled finish.
 - f. Burner: For use with atmospheric, gas-fired, domestic-water heaters and **[natural-gas][LP-gas]**<Insert fuel gas> fuel.
 - g. Ignition: Standing pilot or ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
 - h. Temperature Control: Adjustable thermostat.
 - i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - j. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
7. Special Requirements: NSF 5 construction.
8. Draft Hood: Draft diverter, complying with ANSI Z21.12.
9. Automatic Damper: ANSI Z21.66/CSA 6.14, **[electrically operated][mechanically activated][thermally activated]**, automatic-vent-damper device with size matching draft hood.

B. Commercial, Power-Burner, Gas-Fired, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[Aldrich Company, Inc. (The)]**
 - c. **[Bock Water Heaters, Inc]**
 - d. **[HESco Industries, Inc]**
 - e. **[Precision Boilers]**
 - f. **[PVI; A WATTS Brand]**
 - g. **[State Industries]**

- h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [A. O. Smith Corporation]
 - b. [Aldrich Company, Inc. (The)]
 - c. [Bock Water Heaters, Inc]
 - d. [HESco Industries, Inc]
 - e. [Precision Boilers]
 - f. [PVI; A WATTS Brand]
 - g. [State Industries]
 - h. <Insert manufacturer's name>
3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
4. Standard: ANSI Z21.10.3/CSA 4.3.
5. Storage-Tank Construction: [Non-]ASME-code steel with [150-psig (1035-kPa)]<Insert value> working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 - b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Lining: [Cement][Glass][Nickel plate][Phenolic coating][Sheet copper]<Insert material> complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
6. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
 - e. Jacket: Steel with enameled finish.
 - f. Burner: UL 795 for power-burner, gas-fired, domestic-water heaters and [natural-gas][LP-gas]<Insert fuel gas> fuel.
 - g. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
 - h. Temperature Control: Adjustable thermostat.
 - i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - j. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
7. Special Requirements: NSF 5 construction.

8. Draft Hood: **[Draft diverter, complying with ANSI Z21.12]<Insert different hood or other arrangement>.**

C. Commercial, Power-Vent, Gas-Fired, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[Raypak; a Rheem brand]**
 - e. **[Rheem Manufacturing Company]**
 - f. **[State Industries]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[Raypak; a Rheem brand]**
 - e. **[Rheem Manufacturing Company]**
 - f. **[State Industries]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
4. Standard: ANSI Z21.10.3/CSA 4.3.
5. Storage-Tank Construction: **[Non-]ASME-code steel with [150-psig (1035-kPa)]<Insert value>** working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 - b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Lining: **[Cement][Glass][Nickel plate][Phenolic coating][Sheet copper]<Insert material>** complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
6. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.

- e. Jacket: Steel with enameled finish.
- f. Burner: For use with power-vent, gas-fired, domestic-water heaters and **[natural-gas][LP-gas]<Insert fuel gas>** fuel.
- g. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
- h. Temperature Control: Adjustable thermostat.
- i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
- j. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

- 7. Special Requirements: NSF 5 construction.
- 8. Power-Vent System: Exhaust fan, interlocked with burner.

D. Commercial, Direct-Vent, Gas-Fired, Storage, Domestic-Water Heaters:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Water Heaters]**
 - b. **[Bradford White Corporation]**
 - c. **[GSW Water Heating]**
 - d. **[Lochinvar, LLC]**
 - e. **[Rheem Manufacturing Company]**
 - f. **[State Industries]**
 - g. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Water Heaters]**
 - b. **[Bradford White Corporation]**
 - c. **[GSW Water Heating]**
 - d. **[Lochinvar, LLC]**
 - e. **[Rheem Manufacturing Company]**
 - f. **[State Industries]**
 - g. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
- 4. Standard: ANSI Z21.10.1/CSA 4.1.
- 5. Storage-Tank Construction: Steel.
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **150 psig (1035 kPa)**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
- 6. Factory-Installed Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.

- b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with ASHRAE/IES 90.1.
 - e. Jacket: Steel with enameled finish.
 - f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - g. Burner: For use with direct-vent, gas-fired, domestic-water heaters and **[natural-gas][LP-gas]<Insert fuel gas>** fuel.
 - h. Ignition: Standing pilot or ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
 - i. Temperature Control: Adjustable thermostat.
 - j. Combination Temperature-and-Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.
7. Direct-Vent System: Through-**[wall][roof]**, coaxial- or double-channel vent assembly with domestic-water heater manufacturers' outside intake/exhaust screen.
- E. Commercial, Gas-Fired, High-Efficiency, Storage, Domestic-Water Heaters:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[AERCO; A WATTS Brand]**
 - c. **[American Water Heaters]**
 - d. **[Bock Water Heaters, Inc]**
 - e. **[Bradford White Corporation]**
 - f. **[Heat Transfer Products, Inc]**
 - g. **[PVI; A WATTS Brand]**
 - h. **[Raypak; a Rheem brand]**
 - i. **[Rheem Manufacturing Company]**
 - j. **[State Industries]**
 - k. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[AERCO; A WATTS Brand]**
 - c. **[American Water Heaters]**
 - d. **[Bock Water Heaters, Inc]**
 - e. **[Bradford White Corporation]**
 - f. **[Heat Transfer Products, Inc]**
 - g. **[PVI; A WATTS Brand]**
 - h. **[Raypak; a Rheem brand]**
 - i. **[Rheem Manufacturing Company]**
 - j. **[State Industries]**
 - k. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
 4. Standard: ANSI Z21.10.3/CSA 4.3.
 5. Description: Manufacturer's proprietary design to provide at least **[84][85][88][95]<Insert**

- number**> percent combustion efficiency at optimum operating conditions.
6. Storage-Tank Construction: ASME-code steel with **[150-psig (1035-kPa)]<Insert value>** minimum working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 - b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Lining: **[Cement][Glass][Nickel plate][Phenolic coating][Sheet copper]<Insert material>** complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
 7. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
 - e. Jacket: Steel with enameled finish.
 - f. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and **[natural-gas][LP-gas]<Insert fuel gas>** fuel.
 - g. Temperature Control: Adjustable thermostat.
 - h. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - i. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
 8. Draft Hood: **[Draft diverter, complying with ANSI Z21.12]<Insert different hood or other arrangement>**.
- F. Capacity and Characteristics:
1. Capacity: **<Insert gal. (L)>**.
 2. Recovery: **<Insert gph (L/s)>** at **[100 deg F (56 deg C)]<Insert temperature>** temperature rise.
 3. Temperature Setting: **[125 deg F (52 deg C)][140 deg F (60 deg C)]<Insert temperature>**.
 4. Fuel Gas Demand: **<Insert cfh (L/s)>**.
 5. Fuel Gas Input: **<Insert Btu/h (W)>**.
 6. Gas Pressure Regulator:
 - a. Capacity: **<Insert cfh (L/s)>**.
 - b. Inlet Pressure: **<Insert psig (kPa) or inches (mm)>** water column.
 - c. Gas Pressure Required at Burner: **<Insert psig (kPa) or inches (mm)>** water column.
 7. Electrical Characteristics:

- a. Volts: [120][240][277][480]<Insert value> V.
 - b. Phase: [Single][Three].
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: <Insert value> A.
 - e. Minimum Circuit Ampacity: <Insert value> A.
 - f. Maximum Overcurrent Protection: <Insert value> A.
8. Minimum Vent Diameter: <Insert inches (mm)>.

2.3 COMMERCIAL, FINNED-TUBE, GAS-FIRED, DOMESTIC-WATER HEATERS

A. Commercial, Coil-Type, Finned-Tube, Gas-Fired, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [A. O. Smith Corporation]
 - b. [CAMUS Hydronics Ltd.]
 - c. [IBC Technologies; a Rheem brand]
 - d. [Laars Heating Systems Company; a subsidiary of Bradford White Corporation]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [A. O. Smith Corporation]
 - b. [CAMUS Hydronics Ltd.]
 - c. [IBC Technologies; a Rheem brand]
 - d. [Laars Heating Systems Company; a subsidiary of Bradford White Corporation]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
4. Standard: ANSI Z21.13/CSA 4.9 for hot-water-supply boilers.
5. Description: Packaged unit with boiler, separate hot-water storage tank, pump, piping, and controls.
6. Boiler Construction: ASME code with [160-psig (1100-kPa)]<Insert value> working-pressure rating for hot-water-supply boiler, domestic-water heater.
 - a. Heat Exchanger: Helix or spiral, finned-copper-tube coils with bronze headers.
 - b. Connections: Factory fabricated of materials compatible with boiler. Attach to boiler before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
7. Boiler Appurtenances:
 - a. Insulation: Comply with ASHRAE/IES 90.1. Surround entire boiler except connections and controls.
 - b. Jacket: Steel with enameled finish.

- c. Burner: For use with coil-type, finned-tube, gas-fired, domestic-water heaters and **[natural-gas][LP-gas]<Insert fuel gas>** fuel.
 - d. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 60730-2-5, intermittent electronic-ignition system.
 - e. Temperature Control: Adjustable, storage-tank temperature-control fitting and flow switch, interlocked with circulator and burner.
 - f. Safety Control: Automatic, high-temperature-limit cutoff device or system.
- 8. Support: Steel base or skids.
 - 9. Draft Hood: **[Draft diverter, complying with ANSI Z21.12]<Insert different hood or other arrangement>**.
 - 10. Automatic Damper: ANSI Z21.66/CSA 6.14, **[electrically operated][mechanically activated][thermally activated]**, automatic-vent-damper device with size matching draft hood.
 - 11. Hot-Water Storage Tank: Connected with piping to circulating pump and domestic-water heater.
 - a. Construction: In accordance with ASME Boiler and Pressure Vessel Code: Section VIII, steel with **[150-psig (1035-kPa)][125-psig (860-kPa)]<Insert value>** working-pressure rating.
 - b. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 12. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rods: Factory installed, magnesium.
 - b. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - c. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
 - d. Jacket: Steel with enameled finish.
 - e. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
 - 13. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, **[125-psig (860-kPa)]<Insert value>** minimum working-pressure rating, and **225 deg F (107 deg C)** continuous-water-temperature rating.
 - 14. Piping: Copper tubing; copper, solder-joint fittings; and brazed or flanged joints.
 - 15. Mounting: Domestic-water heater, tank, and accessories factory mounted on skids.
- B. Commercial, Grid-Type, Finned-Tube, Gas-Fired, Domestic-Water Heaters:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [A. O. Smith Corporation]
 - b. [CAMUS Hydronics Ltd.]
 - c. [HESco Industries, Inc]
 - d. [Laars Heating Systems Company; a subsidiary of Bradford White Corporation]
 - e. [Lochinvar, LLC]
 - f. [RBI]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [A. O. Smith Corporation]
 - b. [CAMUS Hydronics Ltd.]
 - c. [HESco Industries, Inc]
 - d. [Laars Heating Systems Company; a subsidiary of Bradford White Corporation]
 - e. [Lochinvar, LLC]
 - f. [RBI]
 - g. <Insert manufacturer's name>
3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
4. Standard: ANSI Z21.13/CSA 4.9 for hot-water-supply boilers.
5. Description: Packaged unit with boiler, storage tank, pump, piping, and controls.
6. Boiler Construction: ASME code with [160-psig (1100-kPa)]<Insert value> working-pressure rating for hot-water-boiler-type, domestic-water heater.
 - a. Heat Exchanger: Horizontal, straight, finned-copper tubes with bronze headers.
 - b. Connections: Factory fabricated of materials compatible with boiler. Attach to boiler before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
7. Boiler Appurtenances:
 - a. Insulation: Comply with ASHRAE/IES 90.1. Surround entire boiler except connections and controls.
 - b. Jacket: Steel with enameled finish.
 - c. Burner: For use with grid-type, finned-tube, gas-fired, domestic-water heaters and [natural-gas][LP-gas]<Insert fuel gas> fuel.
 - d. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 60730-2-5, intermittent electronic-ignition system.
 - e. Temperature Control: Adjustable, storage-tank temperature-control fitting and flow switch, interlocked with circulator and burner.
 - f. Safety Control: Automatic, high-temperature-limit cutoff device or system.
8. Support: Steel base or skids.
9. Draft Hood: [Draft diverter, complying with ANSI Z21.12]<Insert different hood or other arrangement>.
10. Automatic Damper: ANSI Z21.66/CSA 6.14, [electrically operated][mechanically activated][thermally activated], automatic-vent-damper device with size matching draft hood.
11. Hot-Water Storage Tank: Connected with piping to circulating pump and domestic-water heater.
 - a. Construction: In accordance with ASME Boiler and Pressure Vessel Code: Section VIII,

- steel with **[150-psig (1035-kPa)][125-psig (860-kPa)]<Insert value>** working-pressure rating.
- b. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
12. Factory-Installed, Storage-Tank Appurtenances:
- a. Anode Rods: Factory installed, magnesium.
 - b. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - c. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
 - d. Jacket: Steel with enameled finish.
 - e. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
13. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, **[125-psig (860-kPa)]<Insert value>** minimum working-pressure rating, and **225 deg F (107 deg C)** continuous-water-temperature rating.
14. Piping: Copper tubing; copper, solder-joint fittings; and brazed or flanged joints.
15. Mounting: Domestic-water heater, tank, and accessories factory mounted on skids.
- C. Capacity and Characteristics:
1. Hot-Water Storage-Tank Capacity: **<Insert gal. (L)>**.
 2. Recovery: **<Insert gph (L/s)>** at **[100 deg F (56 deg C)]<Insert temperature>** temperature rise.
 3. Temperature Setting: **[125 deg F (52 deg C)][140 deg F (60 deg C)]<Insert temperature>**.
 4. Fuel Gas Demand: **<Insert cfh (L/s)>**.
 5. Fuel Gas Input: **<Insert Btu/h (W)>**.
 6. Gas Pressure Regulator:
 - a. Capacity: **<Insert cfh (L/s)>**.
 - b. Inlet Pressure: **<Insert psig (kPa) or inches (mm)>** water column.
 - c. Gas Pressure Required at Burner: **<Insert psig (kPa) or inches (mm)>** water column.
 7. Electrical Characteristics:
 - a. Volts: **[120][240][277][480]<Insert value>** V.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value>** A.
 - e. Minimum Circuit Ampacity: **<Insert value>** A.
 - f. Maximum Overcurrent Protection: **<Insert value>** A.
 8. Minimum Vent Diameter: **<Insert inches (mm)>**.

2.4 GAS-FIRED, TANKLESS, DOMESTIC-WATER HEATERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[A. O. Smith Corporation]**
 2. **[Bosch Thermotechnology Corp.]**
 3. **[Bradford White Corporation]**
 4. **[Intellihot]**
 5. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
 6. **[Navien Inc.]**
 7. **[NORITZ America Corp.]**
 8. **[Rheem Manufacturing Company]**
 9. **[Rinnai Corporation]**
 10. **[State Industries]**
 11. **[Takagi]**
 12. **[WaiWela]**
 13. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[A. O. Smith Corporation]**
 2. **[Bosch Thermotechnology Corp.]**
 3. **[Bradford White Corporation]**
 4. **[Intellihot]**
 5. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
 6. **[Navien Inc.]**
 7. **[NORITZ America Corp.]**
 8. **[Rheem Manufacturing Company]**
 9. **[Rinnai Corporation]**
 10. **[State Industries]**
 11. **[Takagi]**
 12. **[WaiWela]**
 13. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
- D. Standard: ANSI Z21.10.3/CSA 4.3 for gas-fired, instantaneous, domestic-water heaters for indoor application.
- E. Construction: Copper piping or tubing complying with NSF 61 and NSF 372 barrier materials for potable water, without storage capacity.
1. Tappings: ASME B1.20.1 pipe thread.
 2. Pressure Rating: **150 psig (1035 kPa)**.
 3. Heat Exchanger: **[Copper tubing][Stainless steel]**.
 4. Insulation: Comply with **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
 5. Jacket: Metal, with enameled finish, or plastic.
 6. Burner: For use with tankless, domestic-water heaters and **[natural-gas][LP-gas]<Insert fuel gas>** fuel.
 7. Automatic Ignition: Manufacturer's proprietary system for automatic, gas ignition.
 8. Temperature Control: Adjustable thermostat.
- F. Support: Bracket for wall mounting.

G. Capacity and Characteristics:

1. Flow Rate: **<Insert gpm (L/s)>** at **[100 deg F (56 deg C)]<Insert temperature>** temperature rise.
2. Temperature Setting: **[125 deg F (52 deg C)][140 deg F (60 deg C)]<Insert temperature>**.
3. Fuel Gas Demand: **<Insert cfh (L/s)>**.
4. Fuel Gas Input: **<Insert Btu/h (W)>**.
5. Gas Pressure Regulator:
 - a. Capacity: **<Insert cfh (L/s)>**.
 - b. Inlet Pressure: **<Insert psig (kPa) or inches (mm)>** water column.
 - c. Gas Pressure Required at Burner: **<Insert psig (kPa) or inches (mm)>** water column.
6. Electrical Characteristics:
 - a. Volts: **[120]<Insert value>** V.
 - b. Phase: Single.
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value>** A.
 - e. Minimum Circuit Ampacity: **<Insert value>** A.
 - f. Maximum Overcurrent Protection: **<Insert value>** A.
7. Minimum Vent Diameter: **<Insert inches (mm)>**.

2.5 RESIDENTIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Residential, Atmospheric, Gas-Fired, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[GSW Water Heating]**
 - e. **[Lochinvar, LLC]**
 - f. **[State Industries]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[American Water Heaters]**
 - c. **[Bradford White Corporation]**
 - d. **[GSW Water Heating]**
 - e. **[Lochinvar, LLC]**
 - f. **[State Industries]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
4. Standard: ANSI Z21.10.1/CSA 4.1.

5. Storage-Tank Construction: Steel.
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **150 psig (1035 kPa)**.
 - c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 6. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
 - e. Jacket: Steel with enameled finish.
 - f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - g. Burner: For use with atmospheric, gas-fired, domestic-water heaters and **[natural-gas][LP-gas]<Insert fuel gas>** fuel.
 - h. Ignition: Standing pilot or ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
 - i. Temperature Control: Adjustable thermostat.
 - j. Combination Temperature-and-Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.
 7. Draft Hood: Low-profile-type draft diverter, complying with ANSI Z21.12.
 8. Automatic Damper: ANSI Z21.66/CSA 6.14, **[electrically operated][mechanically activated][thermally activated]**, automatic-vent-damper device with size matching draft hood.
- B. Residential, Direct-Vent, Gas-Fired, Storage, Domestic-Water Heaters:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[Bradford White Corporation]**
 - c. **[Lochinvar, LLC]**
 - d. **[State Industries]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[Bradford White Corporation]**
 - c. **[Lochinvar, LLC]**
 - d. **[State Industries]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
 4. Standard: ANSI Z21.10.1/CSA 4.1.
 5. Storage-Tank Construction: Steel.

- a. Tappings: ASME B1.20.1 pipe thread.
- b. Pressure Rating: **150 psig (1035 kPa)**.
- c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.

6. Factory-Installed, Storage-Tank Appurtenances:

- a. Anode Rod: Replaceable magnesium.
- b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
- c. Drain Valve: Corrosion-resistant metal with hose-end connection.
- d. Insulation: Comply with **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
- e. Jacket: Steel with enameled finish.
- f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
- g. Burner: For use with direct-vent, gas-fired, domestic-water heaters and **[natural-gas][LP-gas]<Insert fuel gas>** fuel.
- h. Ignition: Standing pilot or ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
- i. Temperature Control: Adjustable thermostat.
- j. Combination Temperature-and-Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

- 7. Direct-Vent System: Through-**[wall][roof]**, coaxial- or double-channel vent assembly with domestic-water heater manufacturers' outside intake/exhaust screen.

C. Residential, Power-Vent, Gas-Fired, Storage, Domestic-Water Heaters:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[A. O. Smith Corporation]**
- b. **[American Water Heaters]**
- c. **[Bradford White Corporation]**
- d. **[GSW Water Heating]**
- e. **[Lochinvar, LLC]**
- f. **[State Industries]**
- g. **<Insert manufacturer's name>**

- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[A. O. Smith Corporation]**
- b. **[American Water Heaters]**
- c. **[Bradford White Corporation]**
- d. **[GSW Water Heating]**
- e. **[Lochinvar, LLC]**
- f. **[State Industries]**
- g. **<Insert manufacturer's name>**

- 3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
- 4. Standard: ANSI Z21.10.1/CSA 4.1.

5. Storage-Tank Construction: Steel.
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **150 psig (1035 kPa)**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
6. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
 - e. Jacket: Steel with enameled finish.
 - f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - g. Burner: For use with power-vent, gas-fired, domestic-water heaters and **[natural-gas][LP-gas]<Insert fuel gas>** fuel.
 - h. Ignition: Standing pilot or ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
 - i. Temperature Control: Adjustable thermostat.
 - j. Combination Temperature-and-Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

7. Power-Vent System: Exhaust fan, interlocked with burner.

D. Capacity and Characteristics:

1. Capacity: **<Insert gal. (L)>**.
2. Recovery: **<Insert gph (L/s)>** at **[100 deg F (56 deg C)]<Insert temperature>** temperature rise.
3. Temperature Setting: **[125 deg F (52 deg C)]<Insert temperature>**.
4. Fuel Gas Demand: **<Insert cfh (L/s)>**.
5. Fuel Gas Input: **<Insert Btu/h (W)>**.
6. Gas Pressure Regulator:

- a. Capacity: **<Insert cfh (L/s)>**.
- b. Inlet Pressure: **<Insert psig (kPa) or inches (mm)>** water column.
- c. Gas Pressure Required at Burner: **<Insert psig (kPa) or inches (mm)>** water column.

7. Electrical Characteristics:

- a. Volts: **[120][240]<Insert value>** V.
- b. Phase: **[Single][Three]**.
- c. Hertz: 60 Hz.
- d. Full-Load Amperes: **<Insert value>** A.
- e. Minimum Circuit Ampacity: **<Insert value>** A.
- f. Maximum Overcurrent Protection: **<Insert value>** A.

8. Minimum Vent Diameter: **<Insert inches (mm)>**.

2.6 OIL-FIRED, DOMESTIC-WATER HEATERS

A. Commercial, Oil-Fired, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[Aldrich Company, Inc. (The)]**
 - c. **[Bock Water Heaters, Inc]**
 - d. **[Precision Boilers]**
 - e. **[State Industries]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[Aldrich Company, Inc. (The)]**
 - c. **[Bock Water Heaters, Inc]**
 - d. **[Precision Boilers]**
 - e. **[State Industries]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
4. Standard: UL 732 for storage, domestic-water heaters.
5. Storage-Tank Construction: **[Non-]ASME-code** steel with **[150-psig (1035-kPa)]<Insert value>** minimum working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 - b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Lining: **[Cement][Glass][Nickel plate][Phenolic coating][Sheet copper]<Insert material>** complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
6. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with ASHRAE/IES 90.1.
 - e. Jacket: Steel with enameled finish.
 - f. Temperature Control: Adjustable thermostat.
 - g. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

7. Oil Burners:

- a. Standard: UL 296 for use with No. 2 fuel oil.
- b. Safety Control: Automatic, high-temperature-limit cutoff device or system.
- c. Draft Regulator: Barometric type or adjustable-damper device.

B. Commercial, Large-Volume, Oil-Fired, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[A. O. Smith Corporation]**
 - b. **[Aldrich Company, Inc. (The)]**
 - c. **[Bock Water Heaters, Inc]**
 - d. **[Precision Boilers]**
 - e. **[PVI; A WATTS Brand]**
 - f. **[State Industries]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[Aldrich Company, Inc. (The)]**
 - c. **[Bock Water Heaters, Inc]**
 - d. **[Precision Boilers]**
 - e. **[PVI; A WATTS Brand]**
 - f. **[State Industries]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
4. Standard: UL 732 for storage, domestic-water heaters except when capacity is greater than **120 gal. (454 L)**.
5. Storage-Tank Construction: ASME-code steel with **[150-psig (1035-kPa)]<Insert value>** minimum working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 - b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Lining: **[Cement][Glass][Nickel plate][Phenolic coating][Sheet copper]<Insert material>** complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
6. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.

- b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
- c. Drain Valve: Corrosion-resistant metal with hose-end connection.
- d. Insulation: Comply with ASHRAE/IES 90.1.
- e. Jacket: Steel with enameled finish.
- f. Temperature Control: Adjustable thermostat.
- g. Safety Control: Automatic, high-temperature-limit cutoff device or system.
- h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

7. Oil Burners:

- a. Standard: UL 296 for use with No. 2 fuel oil.
- b. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
- c. Draft Regulator: Barometric type or adjustable-damper device.

C. Residential, Oil-Fired, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bock Water Heaters, Inc]**
 - b. **[Therma-Flow/Everhot]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bock Water Heaters, Inc]**
 - b. **[Therma-Flow/Everhot]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
4. Standard: UL 732 for storage, domestic-water heaters.
5. Storage-Tank Construction: Steel.
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: **150 psig (1035 kPa)**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
6. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with **[ASHRAE/IES 90.1][ASHRAE 90.2]**.
 - e. Jacket: Steel with enameled finish.
 - f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - g. Temperature Control: Adjustable thermostat.

- h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
 7. Oil Burner: UL 296 for use with No. 2 fuel oil.
 8. Draft Regulator: Barometric type or adjustable-damper device.
- D. Capacity and Characteristics:
1. Capacity: **<Insert gal. (L)>**.
 2. Recovery: **<Insert gph (L/s)>** at **[100 deg F (56 deg C)]<Insert temperature>** temperature rise.
 3. Temperature Setting: **[125 deg F (52 deg C)][140 deg F (60 deg C)]<Insert temperature>**.
 4. Fuel-Oil Demand: **<Insert gpm (kg/s)>**.
 5. Fuel-Oil Input: **<Insert Btu/h (W)>**.
 6. Electrical Characteristics:
 - a. Burner Horsepower: **<Insert value>**.
 - b. Volts: **[120][240][277][480]<Insert value> V**.
 - c. Phase: **[Single][Three]**.
 - d. Hertz: 60 Hz.
 - e. Full-Load Amperes: **<Insert value> A**.
 - f. Minimum Circuit Ampacity: **<Insert value> A**.
 - g. Maximum Overcurrent Protection: **<Insert value> A**.
 7. Minimum Vent Diameter: **<Insert inches (mm)>**.

2.7 COMMERCIAL, GAS- AND OIL-FIRED, DOMESTIC-WATER HEATERS

- A. Description: Comply with ANSI Z21.10.3/CSA 4.3 or UL 732 requirements appropriate for dual-fuel, gas- and oil-fired, domestic-water heaters.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[A. O. Smith Corporation]**
 2. **[Bock Water Heaters, Inc]**
 3. **[HESco Industries, Inc]**
 4. **[Precision Boilers]**
 5. **[PVI; A WATTS Brand]**
 6. **[State Industries]**
 7. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[A. O. Smith Corporation]**
 2. **[Bock Water Heaters, Inc]**
 3. **[HESco Industries, Inc]**
 4. **[Precision Boilers]**
 5. **[PVI; A WATTS Brand]**
 6. **[State Industries]**
 7. **<Insert manufacturer's name>**

- D. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
- E. Storage-Tank Construction: ASME-code steel with [150-psig (1035-kPa)]<Insert value> minimum working-pressure rating.
1. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - a. NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - b. NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 2. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 3. Lining: [Cement][Glass][Nickel plate][Phenolic coating][Sheet copper]<Insert material> complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
- F. Factory-Installed, Storage-Tank Appurtenances:
1. Anode Rod: Replaceable magnesium.
 2. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 3. Drain Valve: Corrosion-resistant metal with hose-end connection.
 4. Insulation: Comply with ASHRAE/IES 90.1.
 5. Jacket: Steel with enameled finish.
 6. Temperature Control: Adjustable thermostat.
 7. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
- G. Fuel Burner:
1. Standards: Combination gas-and-oil burner assembly, complying with appropriate requirements of UL 795; or comply with UL 296 for oil burners for No. 2 fuel oil and UL 795 for [natural-gas][LP-gas]<Insert fuel gas> fuel.
 2. Safety Control: Automatic, high-temperature-limit cutoff device or system.
 3. Vent Connection: In accordance with standards of authorities having jurisdiction for dual-fuel, domestic-water heaters.
- H. Capacity and Characteristics:
1. Capacity: <Insert gal. (L)>.
 2. Recovery: <Insert gph (L/s)> at [100 deg F (56 deg C)]<Insert temperature> temperature rise.
 3. Temperature Setting: [125 deg F (52 deg C)][140 deg F (60 deg C)]<Insert temperature>.
 4. Fuel Gas Demand: <Insert cfh (L/s)>.
 5. Fuel Gas Input: <Insert Btu/h (W)>.
 6. Gas Pressure Regulator:
 - a. Capacity: <Insert cfh (L/s)>.
 - b. Inlet Pressure: <Insert psig (kPa) or inches (mm)> water column.
 - c. Gas Pressure Required at Burner: <Insert psig (kPa) or inches (mm)> water column.
 7. Fuel-Oil Demand: <Insert gpm (kg/s)>.

8. Fuel-Oil Input: **<Insert Btu/h (W)>**.
9. Electrical Characteristics:
 - a. Burner Horsepower: **<Insert value>**.
 - b. Volts: **[120][240]<Insert value> V**.
 - c. Phase: **[Single][Three]**.
 - d. Hertz: 60 Hz.
 - e. Full-Load Amperes: **<Insert value> A**.
 - f. Minimum Circuit Ampacity: **<Insert value> A**.
 - g. Maximum Overcurrent Protection: **<Insert value> A**.
10. Minimum Vent Diameter: **<Insert inches (mm)>**.

2.8 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A. O. Smith Corporation]**
 - b. **[AMTROL, Inc.]**
 - c. **[Flexcon Industries]**
 - d. **[Honeywell International Inc.]**
 - e. **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - f. **[State Industries]**
 - g. **[Taco Comfort Solutions]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A. O. Smith Corporation]**
 - b. **[AMTROL, Inc.]**
 - c. **[Flexcon Industries]**
 - d. **[Honeywell International Inc.]**
 - e. **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - f. **[State Industries]**
 - g. **[Taco Comfort Solutions]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
4. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
5. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.

6. Capacity and Characteristics:
 - a. Working-Pressure Rating: [100 psig (690 kPa)][150 psig (1035 kPa)]<Insert value>.
 - b. Capacity Acceptable: [2 gal. (7.6 L)][4 gal. (15.1 L)][7 gal. (26.5 L)][10 gal. (37.9 L)]<Insert value> minimum.
 - c. Air Precharge Pressure: <Insert system pressure>.
- B. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than **NPS 3/4 (DN 20)** with ASME B1.20.1 pipe threads.
- C. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with ASHRAE/IES 90.1.
- D. Heat-Trap Fittings: ASHRAE 90.2.
- E. Manifold Kits: Domestic-water heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball-, butterfly-, or gate-type shutoff valves to isolate each domestic-water heater and [calibrated][memory-stop] balancing valves to provide balanced flow through each domestic-water heater.
- F. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
 1. Comply with requirements for balancing valves specified in Section 221119 "Domestic Water Piping Specialties."
- G. Gas Shutoff Valves: ANSI Z21.15/CSA 9.1, manually operated. Furnish for installation in piping.
- H. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include [1/2-psig (3.5-kPa)][2-psig (13.8-kPa)][5-psig (34.5-kPa)] pressure rating as required to match gas supply.
- I. Automatic Gas Valves: ANSI Z21.21/CSA 6.5, appliance, electrically operated, on-off automatic valve.
- J. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.
 1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4.
 2. Oil-Fired, Domestic-Water Heaters: ASME rated and stamped.
- K. Pressure Relief Valves: Include pressure setting less than working-pressure rating of domestic-water heater.
 1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4.
 2. Oil-Fired, Domestic-Water Heaters: ASME rated and stamped.
- L. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.
- M. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Provide dimension that will support bottom of domestic-water heater minimum of [18 inches (457 mm)]<Insert dimension> above the floor.
- N. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.9 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect assembled domestic-water heaters[**and storage tanks**] specified to be ASME-code construction, in accordance with ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test[**commercial**] domestic-water heaters[**and storage tanks**] to minimum of one and one-half times pressure rating before shipment.
- C. Domestic-water heaters will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF DOMESTIC-WATER HEATER

- A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
 - 2. Maintain manufacturer's recommended clearances.
 - 3. Arrange units so controls and devices that require servicing are accessible.
 - 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
 - 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 7. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 8. Anchor domestic-water heaters to substrate.
- B. Residential, Domestic-Water Heater Mounting: Install residential domestic-water heaters on **[floor][water-heater stand on floor][domestic-water heater mounting bracket]**.
 - 1. Maintain manufacturer's recommended clearances.
 - 2. Arrange units so controls and devices that require servicing are accessible.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 5. Anchor domestic-water heaters to substrate.
- C. Tankless, Domestic-Water Heater Mounting: Install tankless, domestic-water heaters[**at least 18 inches (457 mm) above floor**] on wall bracket.
 - 1. Maintain manufacturer's recommended clearances.
 - 2. Arrange units so controls and devices that require servicing are accessible.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 5. Anchor domestic-water heaters to substrate.
- D. Install domestic-water heaters level and plumb, in accordance with layout drawings, original design, and

referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- E. Install gas-fired, domestic-water heaters in accordance with NFPA 54.
1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
 2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
 3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
 4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in **[Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping.]**
- F. Install oil-fired, domestic-water heaters in accordance with NFPA 31.
1. Install shutoff valves on fuel-oil supply piping to oil-fired water-heater burners without shutoff valves. Comply with requirements for shutoff valves specified in Section 231113 "Facility Fuel-Oil Piping."
- G. Install commercial domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" and Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."
- H. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- I. Install **[combination temperature-and-]**pressure relief valves in water piping for domestic-water heaters without storage. Extend domestic-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- J. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."
- K. Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."
- L. Assemble and install inlet and outlet piping manifold kits for multiple domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each domestic-water heater outlet. Comply with requirements for valves specified in Section 220523 "General-Duty Valves for Plumbing Piping" and comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."
- M. Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without

integral or fitting-type heat traps.

- N. Fill domestic-water heaters with water.
- O. Charge domestic-water expansion tanks with air to required system pressure.
- P. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight.

3.2 PIPING CONNECTIONS

- A. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."
- B. Comply with requirements for fuel-oil piping specified in Section 231113 "Facility Fuel-Oil Piping."
- C. Comply with requirements for gas piping specified in **[Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping."]**
- D. Drawings indicate general arrangement of piping, fittings, and specialties.
- E. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections **[with the assistance of a factory-authorized service representative]**.
- D. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Domestic-water heaters will be considered defective if they do not pass tests and inspections.



- F. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain **[commercial, gas-fired, storage,][gas-fired, tankless][commercial, oil-fired,][commercial, gas- and oil-fired,]** domestic-water heaters. Training shall be a minimum of **[one][two]<Insert duration>** hour(s).

END OF SECTION 22 34 00 00



Task	Specification	Specification Description
22 34 36 13	22 33 00 00	Electric Domestic-Water Heaters
22 34 36 23	23 52 16 00	Condensing Boilers
22 34 36 23	23 52 33 00	Water-Tube Boilers
22 34 46 11	22 34 00 00	Fuel-Fired, Domestic-Water Heaters



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 35 00 00 - DOMESTIC-WATER HEAT EXCHANGERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Shell-and-tube, domestic-water heat exchangers.
2. Instantaneous, domestic-water heaters.
3. Semi-instantaneous, domestic-water heaters.
4. Indirect-fired, storage, domestic-water heaters.
5. Plate, domestic-water heat exchangers.
6. Drainline heat exchangers.
7. Accessories.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. [**Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.**]

B. Sustainable Design Submittals:

1. Product Data: For energy efficiency.
2. Water Heaters: Product Data for water heater compliance with ASHRAE's "Advanced Energy Design Guides."

C. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room drawing or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades. Also indicate the following:

1. Tube removal space, both vertical and/or horizontal as applicable.
2. Structural members to which heat exchangers will be attached.

B. Seismic Qualification Data: Certificates, for domestic-water heat exchangers, water heaters, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Product Certificates: For each type of [**shell-and-tube heat exchanger**][**instantaneous water**

heater][semi-instantaneous water heater][and][plate heat exchanger] from manufacturer.

1. Domestic-Water, Heat-Exchanger Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
2. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For domestic-water heat exchangers and heaters to include in emergency, operation, and maintenance manuals.

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of domestic-water heat exchangers and heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
 - a. Structural failures, including domestic-water heat exchanger, water heater, storage tank, and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
2. Warranty Periods: From date of Substantial Completion.
 - a. Shell-and-Tube, Domestic-Water Heat Exchangers:
 - 1) Tube Coil: **[One]<Insert number>** year(s).
 - 2) Controls and Other Components: **[One]<Insert number>** year(s).
 - b. Instantaneous, Domestic-Water Heaters:
 - 1) Tank: **[Five][10]<Insert number>** years.
 - 2) Tube Coil: **[Five][10]<Insert number>** years.
 - 3) Controls and Other Components: **[Three]<Insert number>** years.
 - c. Semi-Instantaneous, Domestic-Water Heaters:
 - 1) Tank: **[Five]<Insert number>** years.
 - 2) Tube Coil: **[Five]<Insert number>** years.

- 3) Controls and Other Components: **[Three]<Insert number>** years.
- d. Indirect-Fired, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: **[Five]<Insert number>** years.
 - 2) Tube Coil: **[Five]<Insert number>** years.
 - 3) Controls and Other Components: **[Three]<Insert number>** years.
- e. Plate, Domestic-Water Heat Exchangers:
 - 1) Brazed-Plate Type: **[One]<Insert number>** year(s).
 - 2) Plate-and-Frame Type: **[One]<Insert number>** year(s).
- f. Drainline Heat Exchanger: **[One]<Insert number>** year(s).
- g. Compression Tanks: **[One]<Insert number>** year(s).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- B. ASME Compliance: Where ASME-code construction is indicated, fabricate and label heat-exchanger storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- C. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- E. Seismic Performance: Domestic-water heat exchangers and heaters shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **and the unit will be fully operational after the seismic event**."
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 SHELL-AND-TUBE, DOMESTIC-WATER HEAT EXCHANGERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Armstrong Fluid Technology]**
 2. **[Bell & Gossett; a Xylem brand]**
 3. **[Maxi-Therm]**
 4. **[Taco Comfort Solutions]**
 5. **[Thrush Co. Inc.]**

6. **[Wessels Company]**
 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Armstrong Fluid Technology]**
 2. **[Bell & Gossett; a Xylem brand]**
 3. **[Maxi-Therm]**
 4. **[Taco Comfort Solutions]**
 5. **[Thrush Co. Inc.]**
 6. **[Wessels Company]**
 7. **<Insert manufacturer's name>**
- C. Description: Factory-packaged assembly of shell, U-tube heat-exchanger coils, and specialties for heating domestic water with **[heating hot water][steam]** in shells.
- D. Construction:
1. Fabricate and label heat exchanger to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
- E. Configuration: U-tube with removable **[two-pass][four-pass]** bundle.
- F. Shell Materials: Carbon-steel shell with **[150-psig (1035- kPa)]<Insert value>** minimum working-pressure rating.
1. Tappings: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.
 - a. **NPS 2 (DN 50)** and Smaller: Threaded ends according to ASME B1.20.1.
 - b. **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
- G. Head: Cast iron, flanged and bolted to shell.
- H. Heat-Exchanger Coil: **[Double][Single]**-wall, **[copper][copper-nickel]** coils for domestic water. Include pressure rating equal to or greater than heating-fluid-supply pressure.
- I. Relief Valves: ASME rated and stamped for combination temperature- and pressure-relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting of less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
- J. Miscellaneous Components for Heating Hot-Water Unit: Control valve, valves, and piping. **[Include components fitted for pneumatic control.]**
- K. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gauge, thermometer, and piping. **[Include components fitted for pneumatic control.]**
1. Exception: Steam trap is not required if manufacturer's written instructions direct that it not be used.
- L. Stand: Factory fabricated on skid for floor mounting.

- M. Insulation: Complying with ASHRAE/IES 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire shell and nozzle, except connections and controls.
- N. Required Connections: Domestic cold water in; domestic hot water out; **[heating hot-water-][steam]** supply in; **[heating hot water out][condensate return out]**.
- O. Capacity and Characteristics:
 - 1. Domestic Water:
 - a. Recovery: **<Insert gpm (L/s)>** at **[100 deg F (56 deg C)]<Insert temperature>** temperature rise.
 - b. Hot-Water Temperature Setting: **<Insert deg F (deg C)>**.
 - c. Pipe Size: **<Insert NPS (DN)>**.
 - 2. Heating Hot-Water Supply:
 - a. Inlet Temperature: **<Insert deg F (deg C)>**.
 - b. Outlet Temperature: **<Insert deg F (deg C)>**.
 - c. Pipe Size: **<Insert NPS (DN)>**.
 - 3. Steam Supply:
 - a. Inlet Pressure: **<Insert psig (kPa)>**.
 - b. Demand Rate: **<Insert lb/h (kg/s)>**.
 - c. Input Rating: **<Insert Btu/h (kW)>**.
 - d. Steam Pipe Size: **<Insert NPS (DN)>**.
 - e. Condensate Pipe Size: **<Insert NPS (DN)>**.

2.3 INSTANTANEOUS, DOMESTIC-WATER HEATERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Cemline Corporation]**
 - 2. **[Circor Energy/Leslie Controls]**
 - 3. **[Spirax Sarco Limited]**
 - 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Cemline Corporation]**
 - 2. **[Circor Energy/Leslie Controls]**
 - 3. **[Spirax Sarco Limited]**
 - 4. **<Insert manufacturer's name>**
- C. Description: Factory-packaged assembly of heat exchanger, blending valve, controls, and specialties for heating domestic water in coils with steam in shell utilizing feed forward principle design.
- D. Construction: ASME code, with **[cast-iron][or][steel]** shell for steam.
 - 1. Cast-Iron Shell Pressure Rating: **[50 psig (345 kPa)][75 psig (517 kPa)]**.

2. Steel Shell Pressure Rating: **150 psig (1035 kPa)**.
 3. Standard: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
- E. Heat-Exchanger Coils: Spiral-wound, **[double][single]-wall [copper or copper-alloy][stainless steel]** coils for domestic water.
- F. Temperature Control: Adjustable thermostat that operates blending valve and is capable of maintaining outlet water temperature within **4 deg F (2 deg C)** of setting.
- G. Safety Control: Automatic feed forward blending valve actuated by differential pressure.
- H. Miscellaneous Components: Strainers (main and drip), main trap, drip trap, outlet water temperature gauge, steam pressure gauge, and piping.
- I. Stand: Factory-fabricated steel skid for floor mounting.
- J. Insulation: Factory-fabricated and -installed cover placed over top of the exchanger.
- K. Required Connections: Domestic cold water in; domestic hot water out; steam supply in; condensate return out.
- L. Capacity and Characteristics:
1. Domestic Water:
 - a. Recovery: **<Insert gpm (L/s)>** at **[100 deg F (56 deg C)]<Insert temperature>** temperature rise.
 - b. Hot-Water Temperature Setting: **<Insert deg F (deg C)>**.
 - c. Pipe Size: **<Insert NPS (DN)>**.
 2. Steam Supply:
 - a. Inlet Pressure: **<Insert psig (kPa)>**.
 - b. Demand Rate: **<Insert lb/h (kg/s)>**.
 - c. Input Rating: **<Insert Btu/h (kW)>**.
 - d. Steam Pipe Size: **<Insert NPS (DN)>**.
 3. Condensate Pipe Size: **<Insert NPS (DN)>**.
- M. Recirculation Kit: Provide an integrally mounted recirculation package.
- 2.4 SEMI-INSTANTANEOUS, DOMESTIC-WATER HEATERS
- A. Semi-Instantaneous, Heating-Fluid-in-Coil, Packaged, Compact, Less than 100-Gal. (378-L), Domestic-Water Heater:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AERCO; A WATTS Brand]**

- b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [AERCO; A WATTS Brand]
 - b. <Insert manufacturer's name>
3. Description: Factory-packaged assembly of shell, heat-exchanger coils, and specialties for heating domestic water with steam in coils.
4. Construction:
 - a. Fabricate and label heat exchanger to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
5. Configuration: Vertical-stacked helically shaped coils.
6. Shell Materials: Carbon steel, copper-lined shell with [250-psig (1725-kPa)]<Insert value> minimum working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
7. Head: Cast iron, flanged and bolted to shell.
8. Heat-Exchanger Coil: [Double][Single]-wall, [copper][copper-nickel] coils for domestic water. Include pressure rating equal to or greater than heating-fluid supply pressure.
9. Relief Valves: ASME rated and stamped for combination temperature- and pressure-relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting of less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
10. Miscellaneous Components: Strainers, steam-control valve, steam trap, valves, pressure gauge, thermometer, and piping. [Include components fitted for pneumatic control.]
 - a. Exception: Steam trap is not required if manufacturer's written instructions direct that it not be used.
11. Stand: Factory fabricated on skid for floor mounting.
12. Insulation: Complying with ASHRAE/IES 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire shell and nozzle, except connections and controls.
13. Required Connections: Domestic cold water in; domestic hot water out; steam supply in; condensate return out.
14. Capacity and Characteristics:
 - a. Domestic Water:
 - b. Recovery: <Insert gpm (L/s)> at [100 deg F (56 deg C)]<Insert temperature> temperature rise.
 - 1) Hot-Water Temperature Setting: <Insert deg F (deg C)>.
 - 2) Pipe Size: <Insert NPS (DN)>.
 - c. Steam Supply:

- 1) Inlet Pressure: **<Insert psig (kPa)>**.
- 2) Demand Rate: **<Insert lb/h (kg/s)>**.
- 3) Input Rating: **<Insert Btu/h (kW)>**.
- 4) Steam Pipe Size: **<Insert NPS (DN)>**.

d. Condensate Pipe Size: **<Insert NPS (DN)>**.

B. Semi-Instantaneous, Heating-Fluid-in-Shell, Packaged, Compact, Less than 100-Gal. (378-L), Domestic-Water Heat Exchangers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Adamson Global Technology]**
 - b. **[AO Smith]**
 - c. **[Cemline Corporation]**
 - d. **[Electric Heater Company (The)]**
 - e. **[Harsco Industrial, Patterson-Kelley]**
 - f. **[Patterson-Kelley]**
 - g. **[PVI; A WATTS Brand]**
 - h. **[RECO USA]**
 - i. **[Sellers Manufacturing Co]**
 - j. **[Thrush Co. Inc.]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Adamson Global Technology]**
 - b. **[AO Smith]**
 - c. **[Cemline Corporation]**
 - d. **[Electric Heater Company (The)]**
 - e. **[Harsco Industrial, Patterson-Kelley]**
 - f. **[Patterson-Kelley]**
 - g. **[PVI; A WATTS Brand]**
 - h. **[RECO USA]**
 - i. **[Sellers Manufacturing Co]**
 - j. **[Thrush Co. Inc.]**
 - k. **<Insert manufacturer's name>**
3. Description: Factory packaged, less than **100-gal. (378-L)** storage-capacity hot-water storage tank with heat-exchanger coil, circulator, controls, and specialties for heating domestic water with **[heating hot water][steam]** in coil.
4. Flow Pattern: Standard-flow arrangement, with water from bottom of storage tank circulated across heat-exchanger coil and returned to tank. Include hot-water outlet located at top of tank and temperature sensor in tank.
5. Construction:
 - a. Fabricate and label semi-instantaneous domestic-water heater to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
6. Configuration: Vertical or horizontal.

7. Shell Materials: ASME-code, copper-silicon or corrosion-resistant metal with **150-psig (1035-kPa)** working-pressure rating. Include nozzle and head for heat-exchanger tube coil.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
8. Heat-Exchanger Coil: **[Double][Single]** copper or copper-alloy U tubes with tube sheet and supporting baffles. Include heat-exchanger pressure rating equal to or greater than heating-fluid supply pressure.
9. Temperature Control: Adjustable thermostat.
10. Safety Control: Automatic, high-temperature-limit cutoff device or system. Include automatic low-water cutoff device or system.
11. Relief Valves: ASME rated and stamped for combination temperature- and pressure-relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting of less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
12. Gauges: Factory-mounted thermometer and pressure gauge.
13. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, **[125- psig (860-kPa)]<Insert value>** minimum working-pressure rating, and **225 deg F (107 deg C)** continuous-water-temperature rating.
 - a. Pump Control: Sensor for operating pump and control valve.
14. Miscellaneous Components for Heating Hot-Water Units: Control valve, valves, and piping.
15. Miscellaneous Components for Steam Units: Strainers, steam-control valve, steam trap, valves, pressure gauge, thermometer, and piping.
16. Support: Factory mounted on skid for floor mounting.
17. Energy Management System Interface: Normally closed dry contacts for enabling and disabling heat exchanger.
18. Insulation: Complying with ASHRAE/IES 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle, except connections and controls.
19. Required Connections: Domestic cold water in; domestic hot water out; **[heating hot-water][steam]** supply in; **[heating hot water][condensate return]** out.
20. Capacity and Characteristics:
 - a. Domestic Water:
 - b. Recovery: **<Insert gpm (L/s)>** at **[100 deg F (56 deg C)]<Insert temperature>** temperature rise.
 - 1) Hot-Water Temperature Setting: **<Insert deg F (deg C)>**.
 - 2) Pipe Size: **<Insert NPS (DN)>**.
 - c. Heating Hot-Water Supply:
 - 1) Inlet Temperature: **<Insert deg F (deg C)>**.
 - 2) Outlet Temperature: **<Insert deg F (deg C)>**.
 - 3) Pipe Size: **<Insert NPS (DN)>**.
 - d. Steam Supply:

- 1) Inlet Pressure: **<Insert psig (kPa)>**.
- 2) Demand Rate: **<Insert lb/h (kg/s)>**.
- 3) Input Rating: **<Insert Btu/h (kW)>**.
- 4) Steam Pipe Size: **<Insert NPS (DN)>**.

e. Condensate Pipe Size: **<Insert NPS (DN)>**.

2.5 INDIRECT-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Bradford White Corporation]**
2. **[Cemline Corporation]**
3. **[Electric Heater Company (The)]**
4. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
5. **[Niles Steel Tank; a subsidiary of Bradford White Corporation]**
6. **[Patterson-Kelley]**
7. **[PVI; A WATTS Brand]**
8. **[RECO USA]**
9. **[Sellers Manufacturing Co]**
10. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Bradford White Corporation]**
2. **[Cemline Corporation]**
3. **[Electric Heater Company (The)]**
4. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
5. **[Niles Steel Tank; a subsidiary of Bradford White Corporation]**
6. **[Patterson-Kelley]**
7. **[PVI; A WATTS Brand]**
8. **[RECO USA]**
9. **[Sellers Manufacturing Co]**
10. **<Insert manufacturer's name>**

C. Description: Factory-packaged, hot-water storage tank with heat-exchanger coil, **[circulator]**, controls, and specialties for heating domestic water with **[heating hot water][steam]** in coil.

D. Flow Pattern: Standard-flow arrangement, with water from bottom of storage tank circulated across heat-exchanger coil and returned to tank. Include hot-water outlet located at top of tank and temperature sensor in tank.

E. Storage-Tank Construction: **[Non-]ASME-code [steel]<Insert material>** with **[125-psig (860- kPa)][150-psig (1035- kPa)]<Insert value>** working-pressure rating. Include nozzle and head for heat-exchanger tube coil.

1. Configuration: **[Horizontal][Vertical]**.
2. Manhole: **11 by 15 inches (280 by 380 mm)** in **[end head of horizontal][sidewall of vertical]** storage-tank shell.
3. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.

- a. NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
- b. NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
4. Lining: **[Cement][Glass][Nickel][Epoxy/Phenolic coating][Stainless steel]<Insert material>** complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
5. Insulation: Complying with ASHRAE/IES 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle, except connections and controls.
6. Anode Rods: Factory installed, magnesium.
- F. Heat-Exchanger Coil: **[NPS 3/4 (DN 20)][NPS 1-1/4 (DN 32)]<Insert pipe size>** diameter, **[single][double]**-wall copper or copper-alloy U tubes with tube sheet and supporting baffles. Include heat-exchanger pressure rating equal to or greater than heating-fluid supply pressure.
- G. Temperature Control: Adjustable-temperature aquastat, mounted in storage-tank shell head unless otherwise indicated.
- H. Safety Control: Automatic, high-temperature-limit cutoff device or system. Include automatic low-water cutoff device or system.
- I. Relief Valves: ASME rated and stamped for combination temperature- and pressure-relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting of less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
- J. Gauges: Factory-mounted thermometer and pressure gauge.
- K. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, **[125-psig (860- kPa)]<Insert value>** minimum working-pressure rating, and **225 deg F (107 deg C)** continuous-water-temperature rating.
 1. Pump Control: Sensor for operating pump and control valve.
- L. Support: Factory mounted on skids.
- M. Energy Management System Interface: Normally closed dry contacts for enabling and disabling heat exchanger.
- N. Required Connections: Domestic cold water in; domestic hot water out; **[heating hot-water][steam]** supply in; **[heating hot water][condensate return]** out.
- O. Capacity and Characteristics:
 1. Domestic Water:
 - a. Storage Capacity: **<Insert gal. (L)>**.
 - b. Recovery: **<Insert gph (L/s)>** at **[100 deg F (56 (deg C))<Insert temperature>** temperature rise.
 - c. Pipe Size: **<Insert NPS (DN)>**.
 - d. Hot Water Temperature Setting: **<Insert deg F (deg C)>**.
 2. Heating Hot-Water Supply:
 - a. Inlet Temperature: **<Insert deg F (deg C)>**.

- b. Outlet Temperature: **<Insert deg F (deg C)>**.
 - c. Pipe Size: **<Insert NPS (DN)>**.
- 3. Steam Supply:
 - a. Inlet Pressure: **<Insert psig (kPa)>**.
 - b. Demand Rate: **<Insert lb/h (kg/s)>**.
 - c. Input Rating: **<Insert Btu/h (kW)>**.
 - d. Steam Pipe Size: **<Insert NPS (DN)>**.
- 4. Condensate Pipe Size: **<Insert NPS (DN)>**.
- 5. Electrical Characteristics:
 - a. Volts: **<Insert number>**.
 - b. Phases: **<Insert number>**.
 - c. Hertz: **<Insert number>**.
 - d. Full-Load Amperes: **<Insert number>**.
 - e. Minimum Circuit Ampacity: **<Insert number>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.6 PLATE, DOMESTIC-WATER HEAT EXCHANGERS

A. Brazed-Plate, Domestic-Water Heat Exchangers:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Alfa Laval Inc.]**
 - b. **[API Heat Transfer Inc.]**
 - c. **[Armstrong Fluid Technology]**
 - d. **[Bell & Gossett; a Xylem brand]**
 - e. **[Doucette Industries, Inc]**
 - f. **[Kelvion, Inc.]**
 - g. **[Patterson-Kelley]**
 - h. **[Paul Mueller Company]**
 - i. **[Polaris Heat Exchangers]**
 - j. **[Tranter, Inc]**
 - k. **[Triangle Tube]**
 - l. **[Wessels Company]**
 - m. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alfa Laval Inc.]**
 - b. **[API Heat Transfer Inc.]**
 - c. **[Armstrong Fluid Technology]**
 - d. **[Bell & Gossett; a Xylem brand]**
 - e. **[Doucette Industries, Inc]**
 - f. **[Kelvion, Inc.]**
 - g. **[Patterson-Kelley]**

- h. [Paul Mueller Company]
 - i. [Polaris Heat Exchangers]
 - j. [Tranter, Inc]
 - k. [Triangle Tube]
 - l. [Wessels Company]
 - m. <Insert manufacturer's name>
 3. Description: Factory-packaged assembly of heat-exchanger plates, permanently brazed together, for using [heating hot water][steam] to heat domestic water.
 4. Working-Pressure Rating: [150 psig (1035 kPa)][200 psig (1380 kPa)]<Insert value> minimum.
 5. Plate Construction: [Vented, double][Single] wall.
 6. Plate Material: Stainless steel.
 7. Plate Thickness: Not less than [0.0197 inch (0.5 mm)][0.024 inch (0.6 mm)].
 8. Connections: Stainless steel, threaded.
 9. Brazing Filler Metal: [Copper][or][nickel].
- B. Frame-and-Plate, Domestic-Water Heat Exchangers:
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Alfa Laval Inc.]
 - b. [API Heat Transfer Inc.]
 - c. [APV; SPX Corporation]
 - d. [Armstrong Fluid Technology]
 - e. [Bell & Gossett; a Xylem brand]
 - f. [Flo Fab Inc]
 - g. [Kelvion, Inc.]
 - h. [Paul Mueller Company]
 - i. [Polaris Heat Exchangers]
 - j. [Tranter, Inc]
 - k. [Wessels Company]
 - l. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Alfa Laval Inc.]
 - b. [API Heat Transfer Inc.]
 - c. [APV; SPX Corporation]
 - d. [Armstrong Fluid Technology]
 - e. [Bell & Gossett; a Xylem brand]
 - f. [Flo Fab Inc]
 - g. [Kelvion, Inc.]
 - h. [Paul Mueller Company]
 - i. [Polaris Heat Exchangers]
 - j. [Tranter, Inc]
 - k. [Wessels Company]
 - l. <Insert manufacturer's name>
 3. Description: Factory-packaged assembly of nonfixed-position, heat-exchanger plates, with frame, for using [heating hot water][steam] to heat domestic water.
 4. Working-Pressure Rating: [150 psig (1035 kPa)][200 psig (1380 kPa)][250 psig (1725 kPa)][400

5. **psig (2760 kPa)]<Insert value> minimum.**
Frame:
 - a. Carrying and Guide Bars: **[Carbon steel][Stainless steel]<Insert material>.**
 - b. Fixed, Frame Plate; Pressure Plate; Support Column; and Nuts and Bolts: Carbon steel.
 6. Channel Plates:
 - a. Type: **[Vented, double][Single]** wall.
 - b. Material: Stainless steel.
 - c. Plate Thickness: Not less than **[0.0197 inch (0.5 mm)][0.024 inch (0.6 mm)][0.031 inch (0.8 mm)].**
 - d. Gasket Material: Butyl or acrylonitrile-butadiene rubber, suitable for potable water.
 7. Connections: **[Stainless steel]<Insert material>**, suitable for potable water.
 - a. NPS 2 (DN 50) and Smaller: Threaded.
 - b. NPS 2-1/2 (DN 65) and Larger: Flanged.
 8. Protective Shroud: Steel, covering channel plates.
 9. Insulation: Complying with ASHRAE/IES 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire heat exchanger, except connections.
- C. Required Connections: Domestic cold water in; domestic hot water out; **[heating hot water][steam]** supply in; **[heating hot water][condensate return]** out.
- D. Capacity and Characteristics:
1. Heat-Exchanger Surface Area: **<Insert sq. ft. (sq. m)>.**
 2. Number of Plates: **<Insert number>.**
 3. Domestic Water:
 - a. Recovery: **<Insert gph (L/s)> at [100 deg F (56 deg C)]<Insert temperature> temperature rise.**
 - b. Pipe Size: **<Insert NPS (DN)>.**
 - c. Hot-Water Temperature Setting: **<Insert deg F (deg C)>.**
 4. Heating Hot-Water Supply:
 - a. Inlet Temperature: **<Insert deg F (deg C)>.**
 - b. Outlet Temperature: **<Insert deg F (deg C)>.**
 - c. Pipe Size: **<Insert NPS (DN)>.**
 5. Steam Supply:
 - a. Inlet Pressure: **<Insert psig (kPa)>.**
 - b. Demand Rate: **<Insert lb/h (kg/s)>.**
 - c. Input Rating: **<Insert Btu/h (kW)>.**
 - d. Steam Inlet Pipe Size: **<Insert NPS (DN)>.**
 6. Condensate Outlet Pipe Size: **<Insert NPS (DN)>.**

2.7 DRAINLINE HEAT EXCHANGER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Ecodrain]**
 2. **[Ecolnnovation Technologies]**
 3. **[RenewABILITY Energy, Inc.]**
 4. **[WaterFilm Energy, Inc.]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Ecodrain]**
 2. **[Ecolnnovation Technologies]**
 3. **[RenewABILITY Energy, Inc.]**
 4. **[WaterFilm Energy, Inc.]**
 5. **<Insert manufacturer's name>**
- C. Description: Drainline heat exchanger, full-size vertical or horizontal drainage tube with domestic-water preheat coil around drainage tube.
1. Drainage Tube: ASTM B306, Type DWV copper drainage tube of size indicated.
 2. Domestic-Water Preheat Coil: **ASTM B88, Type L (ASTM B88M, Type B)** copper water tube of connection size indicated attached to drainage tube.
 3. Working-Pressure Rating: **150 psig (1035 kPa)** on domestic-water supply tubing.
 4. Standards:
 - a. All surfaces coming into contact with potable water must be NSF approved for potable water applications.
 - b. Thermal effectiveness of heat exchanger shall be certified to CSA B55.1.
 - c. Construction of heat exchanger shall be certified to CSA B55.2.
- D. Capacities and Characteristics:
1. DWV Drainage Tube:
 - a. Size: **[2 inch (DN 50)][3 inch (DN 80)][4 inch (DN 100)]**.
 - b. Unit Length: **<Insert inches (mm)>**.
 2. Domestic-Water Preheat Coil Connection: **[1/2 inch (DN 15)][3/4 inch (DN 20)][1 inch (DN 25)]**.

2.8 ACCESSORIES

- A. Domestic-Water Compression Tanks:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AMTROL, Inc.]**
 - b. **[AO Smith]**

- c. [Flexcon Industries]
 - d. [Honeywell International Inc.]
 - e. [State Industries]
 - f. [Taco Comfort Solutions]
 - g. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [AMTROL, Inc.]
 - b. [AO Smith]
 - c. [Flexcon Industries]
 - d. [Honeywell International Inc.]
 - e. [State Industries]
 - f. [Taco Comfort Solutions]
 - g. <Insert manufacturer's name>
 3. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system operating pressure at tank.
 4. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 barrier materials for potable water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.
 5. Capacity and Characteristics:
 - a. Working Pressure Rating: [100 psig (690 kPa)][150 psig (1035 kPa)]<Insert value>.
 - b. Capacity Acceptable: [2 gal. (7.6 L)][4 gal. (15.1 L)][7 gal. (26.5 L)][10 gal. (37.9 L)]<Insert value> minimum.
 - c. Air Precharge Pressure: <Insert system pressure>.
 - B. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IES 90.1[or ASHRAE 90.2].
 - C. Heat-Trap Fittings: ASHRAE 90.2.
 - D. Combination Temperature- and Pressure-Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than heat-exchanger working-pressure rating. Select relief valves with sensing element that extends into storage tank.
 - E. Pressure-Relief Valves: ASME rated and stamped. Include pressure setting less than heat-exchanger working pressure rating.
 - F. Vacuum-Relief Valves: ANSI Z21.22/CSA 4.4.
- 2.9 SOURCE QUALITY CONTROL
- A. Factory Tests: Test and inspect domestic-water heat exchangers and domestic-water heaters specified to ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

- B. Hydrostatically test domestic-water heat exchangers and domestic-water heaters to minimum of one and one-half times pressure rating before shipment.
- C. Domestic-water heat exchangers and domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF DOMESTIC-WATER HEAT EXCHANGERS AND DOMESTIC-WATER HEATERS

- A. Domestic-Water Heat Exchangers and Domestic-Water Heaters Mounting: Install domestic-water heat exchangers and domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 5. Anchor heat exchangers and heaters to substrate.
- B. Install domestic-water heat exchangers and domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
 - 1. Install shutoff valves on domestic cold-water supply piping to domestic-water heat exchangers and domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
 - 2. Install shutoff valves on heating hot-water piping to domestic-water heat exchangers and domestic-water heaters. Comply with requirements for shutoff valves specified in Section 2305023 "General-Duty Valves for HVAC Piping."
 - 3. Install shutoff valves on steam and condensate piping to domestic-water heat exchangers and domestic-water heaters. Comply with requirements for shutoff valves specified in Section 2305023 "General-Duty Valves for HVAC Piping."
- C. Install domestic-water heat exchangers and domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- D. Install temperature- and pressure-relief valves in top portion of domestic-water storage tank shells. Use relief valves with sensing elements that extend into shells. Extend relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- E. Install **[combination temperature- and]**pressure-relief valves in water piping for domestic-water heat exchangers and domestic-water heaters without storage. Extend relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

- F. Install domestic-water heat exchangers and domestic-water heaters drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in domestic-water piping for heat exchangers and heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."
- G. Install thermometer on each domestic-water heat exchanger and domestic-water heater[**inlet and**] outlet piping, and install thermometer on each heat exchanger and heater heating-fluid[**inlet and**] outlet piping. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."
- H. Install pressure gauges on domestic-water heat exchanger and domestic-water heater heating-fluid piping. Comply with requirements for pressure gauges specified in Section 220500 "Common Work Results for Plumbing."
- I. Fill domestic-water heat exchangers and domestic-water heaters with water.
- J. Charge domestic-water compression tanks with air.

3.2 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping."
- B. Comply with requirements for heating hot-water piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
- C. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
- D. Drawings indicate general arrangement of piping, fittings, and specialties.
- E. Where installing piping adjacent to domestic-water heat exchangers and heaters, allow space for service and maintenance. Arrange piping for easy removal of heat exchangers and heaters.

3.3 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].

D. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Domestic-water heat exchangers and domestic-water heaters will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain domestic-water **[heat exchangers][and][instantaneous][semi-instantaneous][indirect-fired]** domestic-water heaters.

END OF SECTION 22 35 00 00

THIS PAGE INTENTIONALLY LEFT BLANK



Task	Specification	Specification Description
22 35 23 00	22 35 00 00	Domestic-Water Heat Exchangers
22 35 23 13	22 33 00 00	Electric Domestic-Water Heaters
22 35 23 13	22 35 00 00	Domestic-Water Heat Exchangers



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 41 00 00 - RESIDENTIAL PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bathtubs with shower.
2. Bathtub faucets.
3. Hydromassage whirlpool baths.
4. Air massage whirlpool baths.
5. Walk-in baths.
6. Bidets.
7. Lavatories - counter mounted.
8. Lavatories - pedestal.
9. Lavatories - integral-bowl countertop.
10. Lavatories - countertop-mounted bowl.
11. Lavatory faucets.
12. Showers - standard.
13. Showers - accessible.
14. Showers - factory-fabricated cabinet.
15. Shower faucets.
16. Bar sinks.
17. Kitchen sinks.
18. Laundry trays.
19. Sink faucets.
20. Laminar-flow, faucet-spout outlets.
21. Disposers.
22. Hot-water dispensers.
23. Water closets.
24. Toilet seats.
25. Supply fittings.
26. Waste fittings.
27. Grout.

B. Related Requirements:

1. Section 224200 "Commercial Plumbing Fixtures."
2. Section 224300 "Healthcare Plumbing Fixtures."
3. Section 224500 "Emergency Plumbing Fixtures."
4. Section 224600 "Security Plumbing Fixtures."
5. Section 224700 "Drinking Fountains and Water Coolers."

1.2 DEFINITIONS

- A. FRP: Fiberglass-reinforced plastic.
- B. PMMA: Polymethyl methacrylate, also known as "acrylic."

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: For water consumption.
 - 2. Plumbing Fixtures: Provide the following:
 - a. Manufacturer cut sheet indicating water consumption.
 - b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.
 - 3. Plumbing Fixtures: Provide the following:
 - a. Manufacturer cut sheet indicating water consumption.
 - b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.
- C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted plumbing fixtures.
- B. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For plumbing fixtures and faucets to include in emergency, operation, and operation and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Servicing and adjustments of [whirlpool baths][and][walk-in baths].

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Faucet Washers and O-Rings: Equal to [10]<Insert number> percent of amount of each type and size installed.
 - 2. Faucet Cartridges and O-Rings: Equal to [5]<Insert number> percent of amount of each type and size installed.

3. Flushometer-Tank Repair Kits: Equal to **[5]<Insert number>** percent of amount of each type installed, but no fewer than **[two]<Insert number>** of each type.
4. Toilet Seats: Equal to **[5]<Insert number>** percent of amount of each type installed.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of **[walk-in baths][and][whirlpool baths]** that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Structural failures of unit shell.
 - b. Faulty operation of controls, blowers, pumps, heaters, and timers.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 2. Warranty Period for Residential Applications of Shells: **[Five][20][30]<Insert number>** years from date of Substantial Completion.
 3. Warranty Period for Residential Applications of Pumps and Blowers: **[Five][20]<Insert number>** years from date of Substantial Completion.
 4. Warranty Period for Residential Applications of Electronic Controls: **[Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Domestic water faucets intended to convey or dispense water for human consumption are to comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or to be certified in compliance with NSF 61 and NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 BATHTUBS WITH SHOWER

- A. Enameled Cast-Iron Bathtubs :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **<Insert manufacturer's name>**

B. Enameled-Steel Bathtubs :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Bootz]**
 - c. **[Briggs Plumbing Products, Inc]**
 - d. **[Crane Plumbing, LLC; a division of American Standard]**
 - e. **[Eljer, Inc.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Bootz]**
 - c. **[Briggs Plumbing Products, Inc]**
 - d. **[Crane Plumbing, LLC; a division of American Standard]**
 - e. **[Eljer, Inc.]**
 - f. **<Insert manufacturer's name>**

C. FRP Bathtubs :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Aquarius Bathware; a Praxis Company]**
 - c. **[Clarion Bathware]**
 - d. **[Florestone Products Co., Inc.]**
 - e. **[Sterling]**
 - f. **[Swan Surfaces LLC (Swanstone)]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Aquarius Bathware; a Praxis Company]**
 - c. **[Clarion Bathware]**
 - d. **[Florestone Products Co., Inc.]**
 - e. **[Sterling]**
 - f. **[Swan Surfaces LLC (Swanstone)]**
 - g. **<Insert manufacturer's name>**

D. PMMA Bathtubs :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Acryline USA, Inc.]
- b. [American Standard]
- c. [Anzzi; a brand of SWCorp]
- d. [Aqua Bath Company, Inc.]
- e. [Aquarius Bathware; a Praxis Company]
- f. [Aquatic]
- g. [Clarion Bathware]
- h. [Crane Plumbing, LLC; a division of American Standard]
- i. [Florestone Products Co., Inc.]
- j. [Lyons Industries, Inc]
- k. [Mansfield Plumbing Products LLC]
- l. [St. Thomas Creations]
- m. [Swan Surfaces LLC (Swanstone)]
- n. <Insert manufacturer's name>

- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Acryline USA, Inc.]
- b. [American Standard]
- c. [Anzzi; a brand of SWCorp]
- d. [Aqua Bath Company, Inc.]
- e. [Aquarius Bathware; a Praxis Company]
- f. [Aquatic]
- g. [Clarion Bathware]
- h. [Crane Plumbing, LLC; a division of American Standard]
- i. [Florestone Products Co., Inc.]
- j. [Lyons Industries, Inc]
- k. [Mansfield Plumbing Products LLC]
- l. [St. Thomas Creations]
- m. [Swan Surfaces LLC (Swanstone)]
- n. <Insert manufacturer's name>

E. Fixture:

- 1. Standard:

- a. ASME A112.19.1/CSA B45.2 for enameled[-steel][cast-iron] bathtubs.
- b. IAPMO Z124/CSA B45.5 for [FRP][PMMA] plastic bathtubs.

- 2. Bathing Surface: Slip resistant.
- 3. Size: [48 by 30 inches (1219 by 762 mm)][60 by 30 inches (1525 by 762 mm)][66 by 30 inches (1680 by 762 mm)]<Insert dimensions>[with front apron][drop-in type].
- 4. Color: [White]<Insert color>.
- 5. Drain Location: [Left][Right] end.
- 6. Drain: NPS 1-1/2 (DN 40); chrome-plated brass, pop-up waste and overflow.

F. Faucet: <Insert faucet designation from "Bathtub Faucets" Article>.

G. Supply Fittings: Included in faucet.

H. Tub Filler: Chrome-plated-brass diverter spout.

I. Waste Fittings:

1. Standard: ASME A112.18.2/CSA B125.2.
2. Drain: Stainless steel or chrome-plated brass, removable strainer.
3. Overflow: Chrome-plated-brass escutcheon with toggle drain-plug device.
4. Drain Piping:
 - a. **NPS 1-1/2 (DN 40)** cast-brass overflow, P-trap, and waste.
 - b. Schedule 40 **[ABS][or][PVC]**, **NPS 1-1/2 (DN 40)** P-trap, and waste.

2.3 BATHTUB FAUCETS

A. NSF Standard: Comply with NSF61 and NSF 372 for faucet materials that will be in contact with potable water.

B. Pressure-Balance Faucets, Single Handle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Standard]**
 - b. **[Briggs Plumbing Products, Inc]**
 - c. **[Central Brass Company; a Pioneer Industries, Inc. brand]**
 - d. **[Danze, Inc.]**
 - e. **[Gerber Plumbing Fixtures LLC.]**
 - f. **[Lawler Manufacturing Company, Inc]**
 - g. **[Matco-Norca]**
 - h. **[Moen Incorporated]**
 - i. **[POWERS; A Watts Water Technologies Company]**
 - j. **[Speakman Company]**
 - k. **[St. Thomas Creations]**
 - l. **[Sterling]**
 - m. **[Symmons Industries, Inc]**
 - n. **[T&S Brass and Bronze Works, Inc.]**
 - o. **[Wolverine Brass, Inc]**
 - p. **[Zurn Industries, LLC]**
 - q. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Briggs Plumbing Products, Inc]**
 - c. **[Central Brass Company; a Pioneer Industries, Inc. brand]**
 - d. **[Danze, Inc.]**
 - e. **[Gerber Plumbing Fixtures LLC.]**
 - f. **[Lawler Manufacturing Company, Inc]**
 - g. **[Matco-Norca]**
 - h. **[Moen Incorporated]**

- i. [POWERS; A Watts Water Technologies Company]
- j. [Speakman Company]
- k. [St. Thomas Creations]
- l. [Sterling]
- m. [Symmons Industries, Inc]
- n. [T&S Brass and Bronze Works, Inc.]
- o. [Wolverine Brass, Inc]
- p. [Zurn Industries, LLC]
- q. <Insert manufacturer's name>

C. Thermostatic Faucets, Single Handle :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Standard]
 - b. [Lawler Manufacturing Company, Inc]
 - c. [POWERS; A Watts Water Technologies Company]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Standard]
 - b. [Lawler Manufacturing Company, Inc]
 - c. [POWERS; A Watts Water Technologies Company]
 - d. <Insert manufacturer's name>

D. Standards: ASME A112.18.1/CSA B125.1 and ASSE 1016/ASME A112.1016/CSA B125.16.

E. Faucet:

1. Body Material: Solid brass.
2. Finish: Polished chrome plate.
3. Maximum Flow Rate: [2.5 gpm (9.5 L/min.)]<Insert value> unless otherwise indicated.
4. Mounting: [Concealed][Exposed].
5. Operation: Single handle, [push-pull][or][twist-or-rotate] control, with hot- and cold-water indicators.
6. Antiscald Device: [Integral with mixing valve][Separate unit][Not required].
7. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
8. Diverter: In-tub filler spout.
9. Supply Connections: NPS 1/2 (DN 15).

F. Shower Head:

1. Standard: ASME A112.18.1/CSA B125.1.
2. Type: [Ball joint with arm and flange][Without ball joint, but with arm and flange][Ball joint and head integral with mounting flange][Integral with mounting flange][Hand shower. Include wall-mounting device]<Insert type>.
3. Backflow-Prevention Device: ASSE 1014.
4. Shower Head Material: Metallic with chrome-plated finish.
5. Spray Pattern: [Adjustable][Fixed].

6. Integral Volume Control: **[Not required][Required]**.
7. Shower-Arm, Flow-Control Fitting: **[Not required][1.5 gpm (5.7 L/min.)][2.0 gpm (7.6 L/min.)]**.
8. Temperature Indicator: **[Integral with faucet][Not required]**.

G. Bathtub Filler Spout: Chrome-plated brass.

2.4 HYDROMASSAGE WHIRLPOOL BATHS

A. Enameled Cast-Iron Hydromassage Whirlpool Baths :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **<Insert manufacturer's name>**

B. Enameled-Steel Hydromassage Whirlpool Baths :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Mansfield Plumbing Products LLC]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Mansfield Plumbing Products LLC]**
 - c. **<Insert manufacturer's name>**

C. FRP Hydromassage Whirlpool Baths :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Aquarius Bathware; a Praxis Company]**
 - b. **[Best Bath Systems]**

- c. [Clarion Bathware]
 - d. [MAAX]
 - e. [Sterling]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Aquarius Bathware; a Praxis Company]
 - b. [Best Bath Systems]
 - c. [Clarion Bathware]
 - d. [MAAX]
 - e. [Sterling]
 - f. <Insert manufacturer's name>
- D. PMMA Hydromassage Whirlpool Baths :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [American Whirlpool]
 - b. [Aquarius Bathware; a Praxis Company]
 - c. [Aquatic]
 - d. [BainUltra, Inc.]
 - e. [Benjamin Manufacturing Co., Inc.]
 - f. [Clarion Bathware]
 - g. [Clarke Products, Inc]
 - h. [Eljer, Inc.]
 - i. [Jacuzzi Inc.]
 - j. [Jason International, Inc]
 - k. [Jetta Corporation]
 - l. [Mansfield Plumbing Products LLC]
 - m. [Southland Spa & Sauna Inc.]
 - n. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Whirlpool]
 - b. [Aquarius Bathware; a Praxis Company]
 - c. [Aquatic]
 - d. [BainUltra, Inc.]
 - e. [Benjamin Manufacturing Co., Inc.]
 - f. [Clarion Bathware]
 - g. [Clarke Products, Inc]
 - h. [Eljer, Inc.]
 - i. [Jacuzzi Inc.]
 - j. [Jason International, Inc]
 - k. [Jetta Corporation]
 - l. [Mansfield Plumbing Products LLC]
 - m. [Southland Spa & Sauna Inc.]
 - n. <Insert manufacturer's name>

- E. Description: Bathtub with water-jet nozzles and water circulation.
- F. Standards:
1. ASME A112.19.1/CSA B45.2 and UL 1795 for enameled[-steel][cast-iron] hydromassage bathtubs.
 2. ANSI Z124.1.2/CSA B45.5 and UL 1795 for [FRP][PMMA] hydromassage bathtubs.
- G. Fixture:
1. Seating Capacity: [One][Two]<Insert number> person(s).
 2. Bathing Surface: Slip resistant.
 3. Size: [60 by 30 inches (1525 by 762 mm)][66 by 30 inches (1680 by 762 mm)][60 by 42 inches (1525 by 1065 mm)]<Insert dimensions>.
 4. Nominal Water Capacity: <Insert gal. (L)>.
 5. Apron: Matching unit, covering exposed front and sides, and with access panel.
 6. Color: [White]<Insert color>.
 7. Drain Location: [Left][Right] end.
 8. Controls: For pump[, timer,][and water heater].
- H. Faucet:
1. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.
 2. Description: Fixture manufacturer's chrome-plated, solid-brass [individual valves][mixing valve] with over-rim tub filler.
 3. Faucet Standard: ASME A112.18.1/CSA B125.1.
- I. Supplies: **NPS 1/2 (DN 15)** copper tubing with ball, gate, or globe valves.
- J. Waste Fittings:
1. Standard: ASME A112.18.2/CSA B125.2.
 2. Size: **NPS 1-1/2 (DN 40)**.
 3. Drain: Chrome-plated exposed parts; brass pop-up waste and overflow.
 4. Drain Piping:
 - a. Cast- and tubular-brass overflow, P-trap, and waste.
 - b. Schedule 40 [ABS][or][PVC], overflow, P-trap, and waste.
- K. Water-Circulating System: Electric circulating pump complying with ASME A112.19.7/CAS B45.10 and with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application and plastic piping.
- L. Water Heater: Electric, inline complying with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- M. Unit Electrical Characteristics:
1. Volts: [120][240][277][480]<Insert number> V.
 2. Phase(s): [Single][Three].
 3. Hertz: [60]<Insert number> Hz.
 4. Full-Load Amperes: <Insert value> A.
 5. Minimum Circuit Ampacity: <Insert value> A.
 6. Maximum Overcurrent Protection: <Insert value> A.

2.5 AIR MESSAGE WHIRLPOOL BATHS

A. PMMA Air Massage Whirlpool Baths :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Acryline USA, Inc.]**
 - b. **[American Whirlpool]**
 - c. **[Aquatic]**
 - d. **[BainUltra, Inc.]**
 - e. **[Jacuzzi Inc.]**
 - f. **[Jason International, Inc]**
 - g. **[Jetta Corporation]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acryline USA, Inc.]**
 - b. **[American Whirlpool]**
 - c. **[Aquatic]**
 - d. **[BainUltra, Inc.]**
 - e. **[Jacuzzi Inc.]**
 - f. **[Jason International, Inc]**
 - g. **[Jetta Corporation]**
 - h. **<Insert manufacturer's name>**
3. Description: Air massage bathtub with air-injection nozzles.
4. Standards: IAPMO Z124.1.2/ANSI Z124.1.2 and UL 1795.
5. Fixture:
 - a. Seating Capacity: **[One][Two]<Insert number>** person(s).
 - b. Bathing Surface: Slip resistant.
 - c. Size: **[60 by 30 inches (1525 by 762 mm)][66 by 30 inches (1680 by 762 mm)][60 by 42 inches (1525 by 1065 mm)]<Insert dimensions>**.
 - d. Nominal Water Capacity: **<Insert gal. (L)>**.
 - e. Apron: Matching unit, covering exposed front and sides, and with access panel.
 - f. Color: **[White]<Insert color>**.
 - g. Drain Location: **[Left][Right]** end.
6. Controls: For blower[, **timer,**][**and water heater**].
7. Faucet:
 - a. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.
 - b. Description: Fixture manufacturer's chrome-plated, solid-brass **[individual valves][mixing valve]** with over-rim tub filler.
 - c. Faucet Standard: ASME A112.18.1/CSA B125.1.
8. Supplies: **NPS 1/2 (DN 15)** copper tubing with ball, gate, or globe valves.
9. Waste Fittings:

- a. Standard: ASME A112.18.2/CSA B125.2.
- b. Size: **NPS 1-1/2 (DN 40)**.
- c. Drain: Chrome-plated exposed parts; brass pop-up waste and overflow.
- d. Drain Piping:
 - 1) Cast- and tubular-brass overflow, P-trap, and waste.
 - 2) Drain Piping: Schedule 40 **[ABS][or][PVC]**, overflow, P-trap, and waste.
- 10. Water-Circulating System: Electric circulating pump, complying with ASME A112.19.7/CSA B45.10 and with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application and plastic piping.
- 11. Water Heater: Electric, inline complying with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 12. Air-Injection System: Electric **[blower][combination blower/heater]** complying with ASME A112.19.7/CSA B45.10 and with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application and plastic piping.
- 13. Unit Electrical Characteristics:
 - a. Volts: **[120][240][277][480]<Insert value> V**.
 - b. Phase(s): **[Single][Three]**.
 - c. Hertz: **[60]<Insert value> Hz**.
 - d. Full-Load Amperes: **<Insert value> A**.
 - e. Minimum Circuit Ampacity: **<Insert value> A**.
 - f. Maximum Overcurrent Protection: **<Insert value> A**.

2.6 WALK-IN BATHS

- A. Standard Walk-in Baths - Plastic, with Side-Entry Door, Seat, and Faucet :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[BathEase Inc]**
 - c. **[Best Bath Systems]**
 - d. **[BOCA Walk In Tubs]**
 - e. **[Glamour Baths]**
 - f. **[Serenity Walk In Bathtubs]**
 - g. **[Walk In Bathtub Company (The)]**
 - h. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[BathEase Inc]**
 - c. **[Best Bath Systems]**
 - d. **[BOCA Walk In Tubs]**
 - e. **[Glamour Baths]**
 - f. **[Serenity Walk In Bathtubs]**
 - g. **[Walk In Bathtub Company (The)]**

- h. <Insert manufacturer's name>
3. Fixture:
 - a. Standards: IAPMO Z124.1.2/ANSI Z124.1.2.
 - b. Material: **[Plastic][PMMA]<Insert material>**.
 - c. Nominal Size: Approximately **60 by 32 by 21 inches (1525 by 815 by 535 mm)**.
 - d. Skirt: **[Front only][On sides not against walls]**.
 - e. Seat: Integral.
 - f. Grab Bar: Manufacturer's standard.
 - g. Door: Side opening with rubber sealing gasket.
 - h. Door Location: **[Left][Right]** side.
 - i. Drain Location: **[Left][Right]** end.
4. Faucet:
 - a. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.
 - b. Description: Fixture manufacturer's chrome-plated, solid-brass **[individual valves][mixing valve]** with over-rim tub filler. **[Include diverter and hand shower.]**
 - c. Faucet Standard: ASME A112.18.1/CSA B125.1.
 - d. Mounting: Deck.
5. Supplies: **NPS 1/2 (DN 15)** copper tubing with ball, gate, or globe valves.
6. Waste Fittings:
 - a. Standard: ASME A112.18.2/CSA B125.2.
 - b. Size: **NPS 1-1/2 (DN 40)**.
 - c. Drain: Chrome-plated exposed parts; brass pop-up waste and overflow.
 - d. Drain Piping:
 - 1) Cast- and tubular-brass overflow, P-trap, and waste.
 - 2) Schedule 40 **[ABS][or][PVC]**, overflow, P-trap, and waste.
7. Water-Circulating System: Electric circulating pump complying with ASME A112.19.7/CSA B45.10 and with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application and plastic piping.
8. Unit Electrical Characteristics:
 - a. Volts: **[120][240][277][480]<Insert value> V**.
 - b. Phase(s): **[Single][Three]**.
 - c. Hertz: **[60]<Insert value> Hz**.
 - d. Full-Load Amperes: **<Insert value> A**.
 - e. Minimum Circuit Ampacity: **<Insert value> A**.
 - f. Maximum Overcurrent Protection: **<Insert value> A**.
- B. Hydromassage Walk-in Baths - Plastic, with Side-Entry Door, Seat, and Faucet :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[BathEase Inc]**
 - c. **[Glamour Baths]**

- d. [Safety Tubs LLC]
 - e. [Walk In Bathtub Company (The)]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Standard]
 - b. [BathEase Inc]
 - c. [Glamour Baths]
 - d. [Safety Tubs LLC]
 - e. [Walk In Bathtub Company (The)]
 - f. <Insert manufacturer's name>
3. Fixture:
- a. Standards: IAPMO Z124.1.2/ANSI Z124.1.2 and UL 1795.
 - b. Nominal Size: Approximately **60 by 32 by 21 inches (1525 by 815 by 535 mm)**.
 - c. Skirt: **[Front only][On sides not against walls]**.
 - d. Seat: Integral.
 - e. Grab Bar: Manufacturer's standard.
 - f. Door: Side opening with rubber sealing gasket.
 - g. Door Location: **[Left][Right]** side.
 - h. Drain Location: **[Left][Right]** end.
4. Faucet:
- a. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.
 - b. Description: Fixture manufacturer's chrome-plated, solid-brass **[individual valves][mixing valve]** with over-rim tub filler. **[Include diverter and hand shower.]**
 - c. Faucet Standard: ASME A112.18.1/CSA B125.1.
 - d. Mounting: Deck.
5. Supplies: **NPS 1/2 (DN 15)** copper tubing with ball, gate, or globe valves.
6. Waste Fittings:
- a. Standard: ASME A112.18.2/CSA B125.2.
 - b. Size: **NPS 1-1/2 (DN 40)**.
 - c. Drain: Chrome-plated exposed parts; brass pop-up waste and overflow.
 - d. Drain Piping:
 - 1) Cast- and tubular-brass overflow, P-trap, and waste.
 - 2) Drain Piping: Schedule 40 **[ABS][or][PVC]**, overflow, P-trap, and waste.
7. Water-Circulating System: Electric circulating pump complying with ASME A112.19.7/CSA B45.10 and with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application and plastic piping.
8. Unit Electrical Characteristics:
- a. Volts: **[120][240][277][480]<Insert value> V**.
 - b. Phase(s): **[Single][Three]**.
 - c. Hertz: **[60]<Insert value> Hz**.
 - d. Full-Load Amperes: **<Insert value> A**.

- e. Minimum Circuit Ampacity: <Insert value> A.
- f. Maximum Overcurrent Protection: <Insert value> A.

2.7 BIDETS

A. Bidets :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Standard]
 - b. [Anzzi; a brand of SWCorp]
 - c. [Briggs Plumbing Products, Inc]
 - d. [Capizzi]
 - e. [Crane Plumbing, LLC; a division of American Standard]
 - f. [Danze, Inc.]
 - g. [Duravit USA, Inc]
 - h. [Eljer, Inc.]
 - i. [Gerber Plumbing Fixtures LLC.]
 - j. [Mansfield Plumbing Products LLC]
 - k. [St. Thomas Creations]
 - l. [TOTO USA, INC]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Standard]
 - b. [Anzzi; a brand of SWCorp]
 - c. [Briggs Plumbing Products, Inc]
 - d. [Capizzi]
 - e. [Crane Plumbing, LLC; a division of American Standard]
 - f. [Danze, Inc.]
 - g. [Duravit USA, Inc]
 - h. [Eljer, Inc.]
 - i. [Gerber Plumbing Fixtures LLC.]
 - j. [Mansfield Plumbing Products LLC]
 - k. [St. Thomas Creations]
 - l. [TOTO USA, INC]
 - m. <Insert manufacturer's name>
3. Fixture:
 - a. Standard: ASME A112.19.2/CSA B45.1 for vitreous-china bidets.
 - b. Type: With [spray][flushing rim][spray and flushing rim][no spray].
 - c. Hole Punching: Number and spacing to match faucet.
 - d. Mounting: Floor.
 - e. Overflow: [Not required][Required].
 - f. Color: [White]<Insert color>.
4. Faucet:

- a. Standard: ASME A112.18.3.
 - b. Type: Manufacturer's standard with **[vacuum breaker, diverter, and submerged spray][over-rim filling]**, pop-up drain, **[NPS 1-1/4 (DN 32)]** tailpiece, and chrome-plated finish. Include **[manufacturer's standard][cross][lever][wrist-blade]<Insert type>** handles.
- 5. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
 - 6. Waste Fittings: Comply with requirements in "Waste Fittings" Article, except faucet includes pop-up drain.

2.8 LAVATORIES - COUNTER MOUNTED

A. Enameled Cast-Iron Lavatories :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Commercial Enameling Company]**
 - c. **[Eljer, Inc.]**
 - d. **[Sloan Valve Company]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Commercial Enameling Company]**
 - c. **[Eljer, Inc.]**
 - d. **[Sloan Valve Company]**
 - e. **<Insert manufacturer's name>**

B. Enameled-Steel Lavatories :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Bootz]**
 - c. **[Briggs Plumbing Products, Inc]**
 - d. **[Crane Plumbing, LLC; a division of American Standard]**
 - e. **[Eljer, Inc.]**
 - f. **[Mansfield Plumbing Products LLC]**
 - g. **[Sloan Valve Company]**
 - h. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [American Standard]
- b. [Bootz]
- c. [Briggs Plumbing Products, Inc]
- d. [Crane Plumbing, LLC; a division of American Standard]
- e. [Eljer, Inc.]
- f. [Mansfield Plumbing Products LLC]
- g. [Sloan Valve Company]
- h. <Insert manufacturer's name>

C. PMMA Lavatories :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Benjamin Manufacturing Co., Inc.]
 - b. [Meganite Inc.]
 - c. [Royal Baths Manufacturing Co]
 - d. [Sloan Valve Company]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Benjamin Manufacturing Co., Inc.]
 - b. [Meganite Inc.]
 - c. [Royal Baths Manufacturing Co]
 - d. [Sloan Valve Company]
 - e. <Insert manufacturer's name>

D. Solid-Surface Lavatories :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [American Standard]
 - b. [Anzzi; a brand of SWCorp]
 - c. [Bradley Corporation]
 - d. [DuPont de Nemours, Inc.]
 - e. [Formica Corporation]
 - f. [Franke Consumer Products, Inc]
 - g. [inpro Corporation]
 - h. [Meganite Inc.]
 - i. [Rynone Manufacturing Corp.]
 - j. [Sloan Valve Company]
 - k. [Swan Surfaces LLC (Swanstone)]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [American Standard]
- b. [Anzzi; a brand of SWCorp]
- c. [Bradley Corporation]
- d. [DuPont de Nemours, Inc.]
- e. [Formica Corporation]
- f. [Franke Consumer Products, Inc]
- g. [inpro Corporation]
- h. [Meganite Inc.]
- i. [Rynone Manufacturing Corp.]
- j. [Sloan Valve Company]
- k. [Swan Surfaces LLC (Swanstone)]
- l. <Insert manufacturer's name>

E. Stainless Steel Lavatories :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Acorn Engineering Company; a Division of Morris Group International]
 - b. [Aqua Design Manufacturing]
 - c. [Elkay]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Acorn Engineering Company; a Division of Morris Group International]
 - b. [Aqua Design Manufacturing]
 - c. [Elkay]
 - d. <Insert manufacturer's name>

F. Vitreous-China Lavatories :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [American Standard]
 - b. [Barclay Products Limited]
 - c. [Briggs Plumbing Products, Inc]
 - d. [Crane Plumbing, LLC; a division of American Standard]
 - e. [Duravit USA, Inc]
 - f. [Eljer, Inc.]
 - g. [Gerber Plumbing Fixtures LLC.]
 - h. [Kohler Co]
 - i. [Mansfield Plumbing Products LLC]
 - j. [Pelican Int'l]
 - k. [Sloan Valve Company]
 - l. [St. Thomas Creations]
 - m. [Sterling]
 - n. [TOTO USA, INC]

- o. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Standard]
 - b. [Barclay Products Limited]
 - c. [Briggs Plumbing Products, Inc]
 - d. [Crane Plumbing, LLC; a division of American Standard]
 - e. [Duravit USA, Inc]
 - f. [Eljer, Inc.]
 - g. [Gerber Plumbing Fixtures LLC.]
 - h. [Kohler Co]
 - i. [Mansfield Plumbing Products LLC]
 - j. [Pelican Int'l]
 - k. [Sloan Valve Company]
 - l. [St. Thomas Creations]
 - m. [Sterling]
 - n. [TOTO USA, INC]
 - o. <Insert manufacturer's name>

G. Fixture:

- 1. Standard:
 - a. ASME A112.19.1/CSA B45.2 for enameled[**-steel**][**cast-iron**] lavatories.
 - b. IAPMO Z124.3/ANSI Z124.3 for PMMA lavatories.
 - c. ASME A112.19.3/CSA B45.4 for stainless steel lavatories.
 - d. ASME A112.19.2/CSA B45.1 for vitreous-china lavatories.
- 2. Type: [Flat rim with ledge][Self-rimming].
- 3. Oval Nominal Size: [19 by 16 inches (483 by 406 mm)][20 by 17 inches (508 by 432 mm)]<Insert dimensions>.
- 4. Rectangular Nominal Size: [18 by 15 inches (457 by 381 mm)][19 by 16 inches (483 by 406 mm)][20 by 18 inches (508 by 457 mm)][24 by 20 inches (610 by 508 mm)]<Insert dimensions>.
- 5. Round Nominal Size: [18 inches (457 mm)][19 inches (483 mm)]<Insert dimensions> in diameter.
- 6. Faucet-Hole Punching: [One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers].
- 7. Faucet-Hole Location: [None][Rim].
- 8. Color: [Not applicable][White]<Insert color>.

H. Faucet: <Insert lavatory-faucet designation from "Lavatory Faucets" Article>.

I. Supply Fittings: Comply with requirements in "Supply Fittings" Article.

J. Waste Fittings: Comply with requirements in "Waste Fittings" Article.

2.9 LAVATORIES - PEDESTAL

A. Vitreous China, Pedestal Lavatories :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [American Standard]
 - b. [Barclay Products Limited]
 - c. [Briggs Plumbing Products, Inc]
 - d. [Crane Plumbing, LLC; a division of American Standard]
 - e. [Eljer, Inc.]
 - f. [Gerber Plumbing Fixtures LLC.]
 - g. [Kohler Co]
 - h. [Mansfield Plumbing Products LLC]
 - i. [St. Thomas Creations]
 - j. [Sterling]
 - k. [TOTO USA, INC]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Standard]
 - b. [Barclay Products Limited]
 - c. [Briggs Plumbing Products, Inc]
 - d. [Crane Plumbing, LLC; a division of American Standard]
 - e. [Eljer, Inc.]
 - f. [Gerber Plumbing Fixtures LLC.]
 - g. [Kohler Co]
 - h. [Mansfield Plumbing Products LLC]
 - i. [St. Thomas Creations]
 - j. [Sterling]
 - k. [TOTO USA, INC]
 - l. <Insert manufacturer's name>
3. Fixture:
- a. Standard: ASME A112.19.2/CSA B45.1.
 - b. Oval Nominal Size: [20 by 17 inches (508 by 432 mm)][24 by 18 inches (610 by 457 mm)]<Insert dimensions>.
 - c. Rectangular Nominal Size: [18 by 15 inches (457 by 381 mm)][19 by 16 inches (483 by 406 mm)][20 by 18 inches (508 by 457 mm)][24 by 20 inches (610 by 508 mm)]<Insert dimensions>.
 - d. Rectangular Pedestal Nominal Size: [20 by 17 inches (508 by 432 mm)]<Insert dimensions>.
 - e. Oval Pedestal Nominal Size: [20 by 17 inches (508 by 432 mm)]<Insert dimensions>.
 - f. Faucet-Hole Punching: [One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers].
 - g. Faucet-Hole Location: [Top][Front wall][Inclined panel].
 - h. Color: [White]<Insert color>.
4. Faucet: <Insert sink-faucet designation from "Sink Faucets" Article>.
 5. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
 6. Waste Fittings: Comply with requirements in "Waste Fittings" Article.

2.10 LAVATORIES - INTEGRAL-BOWL COUNTERTOP

A. Cultured-Marble Countertop Lavatories :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Capital Marble Creations, Inc.]**
 - b. **[Crane Plumbing, LLC; a division of American Standard]**
 - c. **[Rynone Manufacturing Corp.]**
 - d. **[Tri-City Marble, Inc.]**
 - e. **[Virginia Marble Manufacturers, Inc.]**
 - f. **[Waldorf Marble, Inc.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Capital Marble Creations, Inc.]**
 - b. **[Crane Plumbing, LLC; a division of American Standard]**
 - c. **[Rynone Manufacturing Corp.]**
 - d. **[Tri-City Marble, Inc.]**
 - e. **[Virginia Marble Manufacturers, Inc.]**
 - f. **[Waldorf Marble, Inc.]**
 - g. **<Insert manufacturer's name>**

B. Solid-Surface Countertop Lavatories :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Aristech Surfaces]**
 - b. **[DuPont de Nemours, Inc.]**
 - c. **[Formica Corporation]**
 - d. **[inpro Corporation]**
 - e. **[Meganite Inc.]**
 - f. **[Swan Surfaces LLC (Swanstone)]**
 - g. **[Wilsonart LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aristech Surfaces]**
 - b. **[DuPont de Nemours, Inc.]**
 - c. **[Formica Corporation]**
 - d. **[inpro Corporation]**
 - e. **[Meganite Inc.]**
 - f. **[Swan Surfaces LLC (Swanstone)]**
 - g. **[Wilsonart LLC]**

h. <Insert manufacturer's name>

C. Fixture:

1. Description: Countertop lavatory with integral bowl(s) for mounting on base unit.
2. Backsplash: **[Integral with countertop][Separate, same material as countertop][Not required]**.
3. Overall Rectangular Top Size: **[25 by 17 inches (635 by 432 mm)][31 by 19 inches (787 by 483 mm)][49 by 22 inches (1245 by 559 mm)][73 by 22 inches (1854 by 559 mm)]<Insert dimensions>** with **[one][two][three][four]** bowl(s).
4. Bowl Size: Oval, **[19 by 16 inches (483 by 406 mm)][20 by 17 inches (508 by 432 mm)]<Insert dimensions>**.
5. Faucet-Hole Punching: **[One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]**.
6. Faucet-Hole Location: **[Countertop]<Insert location>**.
7. Color: **[White]<Insert color>**.

2.11 LAVATORIES - COUNTERTOP-MOUNTED BOWL

A. Glass Countertop Lavatories :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Affinity Surfaces; a brand of Domain Industries, Inc.]**
 - b. **[Anzzi; a brand of SWCorp]**
 - c. **[Vitraform, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Affinity Surfaces; a brand of Domain Industries, Inc.]**
 - b. **[Anzzi; a brand of SWCorp]**
 - c. **[Vitraform, Inc.]**
 - d. **<Insert manufacturer's name>**

B. Copper Countertop Lavatories :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Affinity Surfaces; a brand of Domain Industries, Inc.]**
 - b. **[Copper and Brass Sinks Direct]**
 - c. **[Signature Hardware]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. **[Affinity Surfaces; a brand of Domain Industries, Inc.]**
- b. **[Copper and Brass Sinks Direct]**
- c. **[Signature Hardware]**
- d. **<Insert manufacturer's name>**

C. Bronze Countertop Lavatories :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Affinity Surfaces; a brand of Domain Industries, Inc.]**
 - b. **[Signature Hardware]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Affinity Surfaces; a brand of Domain Industries, Inc.]**
 - b. **[Signature Hardware]**
 - c. **<Insert manufacturer's name>**

D. Fixture:

1. General: Countertop lavatory bowl for mounting on base unit.
2. Overall Size: **[17-inch (142-mm) OD]<Insert dimensions>**.
3. Faucet-Hole Punching: **[One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]**.
4. Faucet-Hole Location: **[Countertop][Wall]<Insert location>**.
5. Color: **<Insert color>**.

2.12 LAVATORY FAUCETS

- A. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.
- B. General-Duty, Solid-Brass Lavatory Faucets :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Standard]**
 - b. **[Anzzi; a brand of SWCorp]**
 - c. **[Aqua Design Manufacturing]**
 - d. **[Bradley Corporation]**
 - e. **[BrassTech Inc]**
 - f. **[Central Brass Company; a Pioneer Industries, Inc. brand]**
 - g. **[Chicago Faucets; Geberit Group]**
 - h. **[Danze, Inc.]**

- i. [Delta Faucet Company]
 - j. [Eljer, Inc.]
 - k. [Elkay]
 - l. [Franke Consumer Products, Inc]
 - m. [Gerber Plumbing Fixtures LLC.]
 - n. [Griffin Products, Inc.]
 - o. [GROHE America, Inc]
 - p. [Hansgrohe USA]
 - q. [Houzer, Inc.]
 - r. [Hydrotek International, Inc.]
 - s. [Matco-Norca]
 - t. [Moen Incorporated]
 - u. [Pelican Int'l]
 - v. [Price Pfister, Inc]
 - w. [ProFlo; a Ferguson Enterprises, Inc. brand]
 - x. [Rohl LLC]
 - y. [Speakman Company]
 - z. [T&S Brass and Bronze Works, Inc.]
 - aa. [TOTO USA, INC]
 - bb. [Watermark Designs, Ltd.]
 - cc. [Wolverine Brass, Inc]
 - dd. [Zurn Industries, LLC]
 - ee. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Standard]
 - b. [Anzzi; a brand of SWCorp]
 - c. [Aqua Design Manufacturing]
 - d. [Bradley Corporation]
 - e. [BrassTech Inc]
 - f. [Central Brass Company; a Pioneer Industries, Inc. brand]
 - g. [Chicago Faucets; Geberit Group]
 - h. [Danze, Inc.]
 - i. [Delta Faucet Company]
 - j. [Eljer, Inc.]
 - k. [Elkay]
 - l. [Franke Consumer Products, Inc]
 - m. [Gerber Plumbing Fixtures LLC.]
 - n. [Griffin Products, Inc.]
 - o. [GROHE America, Inc]
 - p. [Hansgrohe USA]
 - q. [Houzer, Inc.]
 - r. [Hydrotek International, Inc.]
 - s. [Matco-Norca]
 - t. [Moen Incorporated]
 - u. [Pelican Int'l]
 - v. [Price Pfister, Inc]
 - w. [ProFlo; a Ferguson Enterprises, Inc. brand]
 - x. [Rohl LLC]
 - y. [Speakman Company]
 - z. [T&S Brass and Bronze Works, Inc.]
 - aa. [TOTO USA, INC]

- bb. **[Watermark Designs, Ltd.]**
- cc. **[Wolverine Brass, Inc]**
- dd. **[Zurn Industries, LLC]**
- ee. **<Insert manufacturer's name>**

C. General-Duty, Copper- or Brass-Underbody Faucets :

1. **Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Standard]**
 - b. **[Briggs Plumbing Products, Inc]**
 - c. **[Delta Faucet Company]**
 - d. **[Eljer, Inc.]**
 - e. **[Gerber Plumbing Fixtures LLC.]**
 - f. **[Moen Incorporated]**
 - g. **[Sterling]**
 - h. **[WhiteRock Corp]**
 - i. **[Wolverine Brass, Inc]**
 - j. **<Insert manufacturer's name>**
2. **Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:**
 - a. **[American Standard]**
 - b. **[Briggs Plumbing Products, Inc]**
 - c. **[Delta Faucet Company]**
 - d. **[Eljer, Inc.]**
 - e. **[Gerber Plumbing Fixtures LLC.]**
 - f. **[Moen Incorporated]**
 - g. **[Sterling]**
 - h. **[WhiteRock Corp]**
 - i. **[Wolverine Brass, Inc]**
 - j. **<Insert manufacturer's name>**

D. Description: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.

E. Standard: ASME A112.18.1/CSA B125.1.

F. Body Material: [General duty, solid brass][General-duty, copper or brass underbody with brass cover plate].

G. Finish: [Polished chrome plate][Polished brass].

H. Maximum Flow Rate: [2.2 gpm (8.3 L/min.)][2.5 gpm (9.5 L/min.)]<Insert value>.

I. Centers: [3-3/8 inches (86 mm)][4 inches (102 mm)][6 inches (152 mm)][8 inches (203 mm)][Single hole][Adjustable].

J. Mounting: [Deck, exposed][Deck, concealed][Back/wall, exposed][Back/wall, concealed].

K. Valve Handle(s): [Lever][Knob][Knob, nonmetallic][Cross, four arm][Wrist blade, 4 inches (102

mm)][Elbow, 6 inches (152 mm)][Push button][Not applicable].

- L. Inlet(s): [NPS 3/8 (DN 10) tubing, plain end][NPS 3/8 (DN 10) tubing, with NPS 1/2 (DN 15) male adaptor][NPS 1/2 (DN 15) male shank][NPS 1/2 (DN 15) female shank].
- M. Spout: [Rigid][Swing][Rigid, gooseneck][Swivel, gooseneck].
- N. Spout Outlet: [Aerator][Spray][Laminar flow][Plain end][Spray, 0.5 gpm (1.5 L/min.)].
- O. Operation: [Compression, manual][Noncompression, manual][Sensor][Self-closing, metering].
- P. Drain: [Pop up][Stopper with chain][Grid].

2.13 SHOWERS - STANDARD

A. FRP Shower, Standard, with Base and Faucet :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Aquarius Bathware; a Praxis Company]
 - b. [Clarion Bathware]
 - c. [Florestone Products Co., Inc.]
 - d. [MAAX]
 - e. [Sterling; a Kohler Company]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Aquarius Bathware; a Praxis Company]
 - b. [Clarion Bathware]
 - c. [Florestone Products Co., Inc.]
 - d. [MAAX]
 - e. [Sterling; a Kohler Company]
 - f. <Insert manufacturer's name>

B. PMMA Shower, Standard, with Base and Faucet :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Acryline USA, Inc.]
 - b. [Anzzi; a brand of SWCorp]
 - c. [Aqua Bath Company, Inc.]
 - d. [Aquarius Bathware; a Praxis Company]
 - e. [Aquatic]
 - f. [Clarion Bathware]
 - g. [Comfort Designs Bathware]

- h. [Jacuzzi Inc.]
 - i. [MAAX]
 - j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Acryline USA, Inc.]
 - b. [Anzzi; a brand of SWCorp]
 - c. [Aqua Bath Company, Inc.]
 - d. [Aquarius Bathware; a Praxis Company]
 - e. [Aquatic]
 - f. [Clarion Bathware]
 - g. [Comfort Designs Bathware]
 - h. [Jacuzzi Inc.]
 - i. [MAAX]
 - j. <Insert manufacturer's name>
- C. Standard: IAPMO Z124.1.2/ANSI Z124.1.2.
 - D. Nominal Size: [36 by 34 inches (915 by 865 mm)][42 by 36 inches (1065 by 915 mm)][43 by 39 inches (1090 by 990 mm)][48 by 34 inches (1219 by 865 mm)]<Insert dimensions>.
 - E. Surround:
 1. One piece or sealed, multiple piece.
 2. One piece.
 - F. Bathing Surface: Slip resistant.
 - G. Color: [White]<Insert color>.
 - H. Drain Location: [Left side][Center][Right side].
 - I. Faucet: <Insert faucet designation from "Shower Faucets" Article>.
- 2.14 SHOWERS - ACCESSIBLE
- A. FRP Shower, Accessible, with Seat, Grab Bar, Base, and Faucet :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Clarion Bathware]
 - b. [Florestone Products Co., Inc.]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Clarion Bathware]
- b. [Florestone Products Co., Inc.]
- c. <Insert manufacturer's name>

B. PMMA Shower, Accessible, with Seat, Grab Bar, Base, and Faucet :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Aqua Bath Company, Inc.]
 - b. [Aquatic]
 - c. [Clarion Bathware]
 - d. [Comfort Designs Bathware]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Aqua Bath Company, Inc.]
 - b. [Aquatic]
 - c. [Clarion Bathware]
 - d. [Comfort Designs Bathware]
 - e. <Insert manufacturer's name>

C. Standards: IAPMO Z124.1.2/ANSI Z124.1.2 and ICC/ANSI A117.1 for roll-in shower compartments.

D. Nominal Size: [60 by 36 inches (1525 by 915 mm)][72 by 36 inches (1830 by 915 mm)]<Insert dimensions>.

E. Surround:

1. One piece or sealed, multiple piece.
2. One piece.

F. Bathing Surface: Slip resistant.

G. Color: [White]<Insert color>.

H. Drain Location: [Left side][Center][Right side].

I. Accessibility Options: Grab bar and bench.

J. Faucet: Shower <Insert faucet designation from "Shower Faucets" Article>.

K. Drain: Grid, NPS 2 (DN 50).

2.15 SHOWERS - FACTORY-FABRICATED CABINET

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be

incorporated into the Work include, but are not limited to, the following]:

1. [Aquatic]
2. [Comfort Designs Bathware]
3. [E. L. Mustee & Sons, Inc]
4. [Stern-Williams Products, LLC.]
5. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Aquatic]
2. [Comfort Designs Bathware]
3. [E. L. Mustee & Sons, Inc]
4. [Stern-Williams Products, LLC.]
5. <Insert manufacturer's name>

- C. Size: [30 by 30 inches (762 by 762 mm)][32 by 32 inches (815 by 815 mm)][36 by 36 inches (915 by 915 mm)][36 by 39 inches (915 by 990 mm)][45 by 39 inches (1145 by 990 mm)]<Insert dimensions>.

- D. Material: [Steel][Composite][Plastic], [front][corner][front and rear] access.

- E. Color: [Not applicable]<Insert color>.

- F. Accessibility Options: Grab bar and bench.

- G. Faucet: <Insert faucet designation from "Shower Faucets" Article>.

- H. Supplies: **NPS 1/2 (DN 15)** copper tubing with shutoff valves.

- I. Drain: Grid, **NPS 2 (DN 50)**.

2.16 SHOWER FAUCETS

- A. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.

- B. Single-Handle, Pressure-Balance Faucets :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [American Standard]
- b. [Briggs Plumbing Products, Inc]
- c. [Central Brass Company; a Pioneer Industries, Inc. brand]
- d. [Danze, Inc.]
- e. [Gerber Plumbing Fixtures LLC.]
- f. [Lawler Manufacturing Company, Inc]
- g. [Matco-Norca]
- h. [Moen Incorporated]
- i. [POWERS; A Watts Water Technologies Company]
- j. [ProFlo; a Ferguson Enterprises, Inc. brand]

- k. [Speakman Company]
- l. [Swan Surfaces LLC (Swanstone)]
- m. [Symmons Industries, Inc]
- n. [T&S Brass and Bronze Works, Inc.]
- o. [Wolverine Brass, Inc]
- p. [Zurn Industries, LLC]
- q. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [American Standard]
- b. [Briggs Plumbing Products, Inc]
- c. [Central Brass Company; a Pioneer Industries, Inc. brand]
- d. [Danzel, Inc.]
- e. [Gerber Plumbing Fixtures LLC.]
- f. [Lawler Manufacturing Company, Inc]
- g. [Matco-Norca]
- h. [Moen Incorporated]
- i. [POWERS; A Watts Water Technologies Company]
- j. [ProFlo; a Ferguson Enterprises, Inc. brand]
- k. [Speakman Company]
- l. [Swan Surfaces LLC (Swanstone)]
- m. [Symmons Industries, Inc]
- n. [T&S Brass and Bronze Works, Inc.]
- o. [Wolverine Brass, Inc]
- p. [Zurn Industries, LLC]
- q. <Insert manufacturer's name>

C. Single-Handle, Thermostatic Faucets :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [American Standard]
- b. [Lawler Manufacturing Company, Inc]
- c. [POWERS; A Watts Water Technologies Company]
- d. [ProFlo; a Ferguson Enterprises, Inc. brand]
- e. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [American Standard]
- b. [Lawler Manufacturing Company, Inc]
- c. [POWERS; A Watts Water Technologies Company]
- d. [ProFlo; a Ferguson Enterprises, Inc. brand]
- e. <Insert manufacturer's name>

D. Two-Handle, Nonpressure-Balance and Nonthermostatic Mixing Faucets :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Barclay Products Limited]**
 - c. **[Briggs Plumbing Products, Inc]**
 - d. **[Danze, Inc.]**
 - e. **[E. L. Mustee & Sons, Inc]**
 - f. **[Gerber Plumbing Fixtures LLC.]**
 - g. **[Mansfield Plumbing Products LLC]**
 - h. **[Matco-Norca]**
 - i. **[Paul Decorative Products]**
 - j. **[Price Pfister, Inc]**
 - k. **[T&S Brass and Bronze Works, Inc.]**
 - l. **[Wolverine Brass, Inc]**
 - m. **[Zurn Industries, LLC]**
 - n. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Barclay Products Limited]**
 - c. **[Briggs Plumbing Products, Inc]**
 - d. **[Danze, Inc.]**
 - e. **[E. L. Mustee & Sons, Inc]**
 - f. **[Gerber Plumbing Fixtures LLC.]**
 - g. **[Mansfield Plumbing Products LLC]**
 - h. **[Matco-Norca]**
 - i. **[Paul Decorative Products]**
 - j. **[Price Pfister, Inc]**
 - k. **[T&S Brass and Bronze Works, Inc.]**
 - l. **[Wolverine Brass, Inc]**
 - m. **[Zurn Industries, LLC]**
 - n. **<Insert manufacturer's name>**

E. Fixture:

1. Description: Include hot- and cold-water indicators, check stops, and **[fixed showerhead, arm, and flange][handheld head complying with ASSE 1014 with arm, flange, hose, and bracket]**. Coordinate faucet inlets with supplies.
2. Standard: ASME A112.18.1/CSA B125.1 **[and ASSE 1016]**.
3. Body Material: **[Solid brass]<Insert material>[with nonmetallic trim]**.
4. Finish: **[Polished chrome plate][Polished brass]<Insert finish>**.
5. Maximum Flow Rate: **[2.5 gpm (9.5 L/min.)]<Insert value>** unless otherwise indicated.
6. Mounting: **[Exposed][Concealed]**.
7. Backflow-Prevention Device for Handheld Shower: **[Required][Not required]**.
8. Operation: **[Compression, manual][Noncompression, manual]**.
9. Antiscald Device: **[Integral with mixing valve][Separate unit][Not required]**.
10. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

F. Supply Connections: [NPS 1/2 (DN 15)][NPS 3/4 (DN 20)].

G. Shower Head:

1. Type: **[Ball joint][Without ball joint][Ball joint and head integral with mounting flange][Integral with mounting flange][Handheld, slide-bar mounted][Handheld, hook mounted]**.
2. Shower Head Material: **[Metallic][Nonmetallic][Combined, metallic and nonmetallic]** with chrome-plated finish.
3. Spray Pattern: **[Fixed][Adjustable]**.
4. Integral Volume Control: **[Required][Not required]**.
5. Shower-Arm, Flow-Control Fitting: **[Not required][1.5 gpm (5.7 L/min.)][2.0 gpm (7.6 L/min.)]**.

2.17 BAR SINKS**A. Enameled Cast-Iron Bar Sink, Single Bowl, Counter Mounted :**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Commercial Enameling Company]**
 - c. **[Eljer, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Commercial Enameling Company]**
 - c. **[Eljer, Inc.]**
 - d. **<Insert manufacturer's name>**

B. Enameled-Steel Bar Sink, Single Bowl, Counter Mounted :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Bootz]**
 - c. **[Commercial Enameling Company]**
 - d. **[Eljer, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Bootz]**
 - c. **[Commercial Enameling Company]**

- d. [Eljer, Inc.]
- e. <Insert manufacturer's name>

C. Solid-Surface Bar Sink, Single Bowl, Counter Mounted :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Franke Consumer Products, Inc]
 - b. [Meganite Inc.]
 - c. [Rynone Manufacturing Corp.]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Franke Consumer Products, Inc]
 - b. [Meganite Inc.]
 - c. [Rynone Manufacturing Corp.]
 - d. <Insert manufacturer's name>

D. Stainless Steel Bar Sink, Single Bowl, Counter Mounted :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Barclay Products Limited]
 - b. [Elkay]
 - c. [Franke Consumer Products, Inc]
 - d. [Griffin Products, Inc.]
 - e. [Houzer, Inc.]
 - f. [Moen Incorporated]
 - g. [Revere Sink]
 - h. [Sterling; a Kohler Company]
 - i. [WhiteRock Corp]
 - j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Barclay Products Limited]
 - b. [Elkay]
 - c. [Franke Consumer Products, Inc]
 - d. [Griffin Products, Inc.]
 - e. [Houzer, Inc.]
 - f. [Moen Incorporated]
 - g. [Revere Sink]
 - h. [Sterling; a Kohler Company]
 - i. [WhiteRock Corp]
 - j. <Insert manufacturer's name>

E. Fixture:**1. Standard:**

- a. ASME A112.19.1/CSA B45.2 for enameled~~[-steel]~~**[cast-iron]** lavatories.
- b. IAMPO Z124.3/ANSI Z124.3 for PMMA lavatories.
- c. IAMPO Z124.3/ANSI Z124.3 for solid-surface lavatories.
- d. ASME A112.19.3/CSA B45.4 for stainless steel lavatories.
- e. ASME A112.19.2/CSA B45.1 for vitreous-china lavatories.

2. Type: [Flat rim with ledge][Self-rimming].**3. Overall Dimensions: <Insert dimensions>.****4. Bowl Dimensions: <Insert dimensions>.****F. Faucet: <Insert sink-faucet designation from "Sink Faucets" Article>.****G. Supply Fittings: Comply with requirements in "Supply Fittings" Article.****H. Waste Fittings: Comply with requirements in "Waste Fittings" Article.****2.18 KITCHEN SINKS****A. Enameled Cast-Iron Kitchen Sink, Counter Mounted :****1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. **[American Standard]**
- b. **[Commercial Enameling Company]**
- c. **[Eljer, Inc.]**
- d. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[American Standard]**
- b. **[Commercial Enameling Company]**
- c. **[Eljer, Inc.]**
- d. **<Insert manufacturer's name>**

B. Enameled-Steel Kitchen Sink, Counter Mounted :**1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. **[American Standard]**
- b. **[Bootz]**
- c. **[Commercial Enameling Company]**

- d. [Eljer, Inc.]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Standard]
 - b. [Bootz]
 - c. [Commercial Enameling Company]
 - d. [Eljer, Inc.]
 - e. <Insert manufacturer's name>
- C. PMMA Kitchen Sink, Counter Mounted :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Gerber Plumbing Fixtures LLC.]
 - b. [Glacier Bay]
 - c. [Lyons Industries, Inc]
 - d. [Sterling; a Kohler Company]
 - e. [Thermocast; a division of ITC Industries]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Gerber Plumbing Fixtures LLC.]
 - b. [Glacier Bay]
 - c. [Lyons Industries, Inc]
 - d. [Sterling; a Kohler Company]
 - e. [Thermocast; a division of ITC Industries]
 - f. <Insert manufacturer's name>
- D. Solid-Surface Kitchen Sink, Counter Mounted :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Anzzi; a brand of SWCorp]
 - b. [Franke Consumer Products, Inc]
 - c. [Swan Surfaces LLC (Swanstone)]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Anzzi; a brand of SWCorp]
 - b. [Franke Consumer Products, Inc]

- c. [Swan Surfaces LLC (Swanstone)]
- d. <Insert manufacturer's name>

E. Stainless Steel Kitchen Sink, Counter Mounted :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Affinity Surfaces; a brand of Domain Industries, Inc.]
 - b. [American Standard]
 - c. [Anzzi; a brand of SWCorp]
 - d. [Elkay]
 - e. [Franke Consumer Products, Inc]
 - f. [Griffin Products, Inc.]
 - g. [Houzer, Inc.]
 - h. [Pelican Int'l]
 - i. [ProFlo; a Ferguson Enterprises, Inc. brand]
 - j. [Revere Sink]
 - k. [Sterling]
 - l. [WhiteRock Corp]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Affinity Surfaces; a brand of Domain Industries, Inc.]
 - b. [American Standard]
 - c. [Anzzi; a brand of SWCorp]
 - d. [Elkay]
 - e. [Franke Consumer Products, Inc]
 - f. [Griffin Products, Inc.]
 - g. [Houzer, Inc.]
 - h. [Pelican Int'l]
 - i. [ProFlo; a Ferguson Enterprises, Inc. brand]
 - j. [Revere Sink]
 - k. [Sterling]
 - l. [WhiteRock Corp]
 - m. <Insert manufacturer's name>

F. Fixture:

1. ASME A112.19.1/CSA B45.2 for enameled[-steel][cast-iron] kitchen sinks.
2. IAMPO Z124.3/ANSI Z124.3 for PMMA kitchen sinks.
3. IAMPO Z124.3/ANSI Z124.3 for solid-surface kitchen sinks.
4. ASME A112.19.3/CSA B45.4 for stainless steel kitchen sinks.
5. Overall Dimensions: <Insert dimensions>.
6. Metal Thickness: [0.038 inch (1.0 mm)][0.050 inch (1.3 mm)]<Insert dimension>.
7. Bowl:
 - a. Dimensions: <Insert dimensions>.
 - b. Drain: 3-1/2-inch (89-mm) [crumb cup][grid][outlet for disposer].

- 1) Location: **[Centered in bowl][Near back of bowl]<Insert location>**.
8. Left Bowl:
- a. Dimensions: **<Insert dimensions>**.
 - b. Drain: **3-1/2-inch (89-mm) [crumb cup][grid][grid with offset waste][outlet for disposer]**.
- 1) Location: **[Centered in bowl][Near back of bowl]<Insert location>**.
9. Right Bowl:
- a. Dimensions: **<Insert dimensions>**.
 - b. Drain: **3-1/2-inch (89-mm) [crumb cup][grid][grid with offset waste][outlet for disposer]**.
- 1) Location: **[Centered in bowl][Near back of bowl]<Insert location>**.
10. Center Bowl:
- a. Dimensions: **<Insert dimensions>**.
 - b. Drain: **[1-1/2-inch (38-mm)][3-1/2-inch (89-mm)][crumb cup][grid][grid with offset waste]**.
- 1) Location: **[Centered in bowl]<Insert location>**.
- G. Faucet: **<Insert sink-faucet designation from "Sink Faucets" Article>**.
- H. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
- I. Waste Fittings: Comply with requirements in "Waste Fittings" Article, except include continuous waste for multibowl sinks.
1. Disposer: **[Not required]<Insert disposer designation from "Disposers" Article>**.
 2. Hot-Water Dispenser: **[Not required][Comply with requirements in "Hot-Water Dispensers" Article]**.
- 2.19 LAUNDRY TRAYS
- A. Laundry Trays - Enameled Cast Iron :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Commercial Enameling Company]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Commercial Enameling Company]**

- b. <Insert manufacturer's name>
- 3. Fixture:
 - a. Standard: ASME A112.19.1/CSA B45.2.
 - b. Nominal Size: [24 by 21 inches (610 by 535 mm)][24 by 23 inches (610 by 584 mm)]<Insert dimensions>.
 - c. Color: [White]<Insert color>.
 - d. Mounting: [Freestanding on manufacturer's standard metal stand][Flush, counter mounted with stainless steel ring and sealant or on-counter mounted with sealant].
- 4. Faucet: <Insert sink-faucet designation from "Sink Faucets" Article>.
- 5. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
- 6. Waste Fittings: Comply with requirements in "Waste Fittings" Article.

B. Laundry Trays - Plastic :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [E. L. Mustee & Sons, Inc]
 - b. [Fiat Products]
 - c. [Florestone Products Co., Inc.]
 - d. [Gerber Plumbing Fixtures LLC.]
 - e. [Swan Surfaces LLC (Swanstone)]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [E. L. Mustee & Sons, Inc]
 - b. [Fiat Products]
 - c. [Florestone Products Co., Inc.]
 - d. [Gerber Plumbing Fixtures LLC.]
 - e. [Swan Surfaces LLC (Swanstone)]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
- 3. Fixture:
 - a. Standard: IAPMO Z124.6/ANSI Z124.6.
 - b. Style: Flat-rim ledge.
 - c. Material: [Plastic][Cast polymer][FRP][PMMA][or][PP].
 - d. Nominal Size: [24 by 21 inches (610 by 535 mm)][25 by 22 inches (635 by 559 mm)]<Insert dimensions>.
 - e. Color: [White]<Insert color>.
 - f. Mounting: Freestanding on manufacturer's standard legs or separate, painted-steel stand.
- 4. Faucet: <Insert sink-faucet designation from "Sink Faucets" Article>.
- 5. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
- 6. Waste Fittings: Comply with requirements in "Waste Fittings" Article.

2.20 SINK FAUCETS

- A. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.
- B. General-Duty, Solid-Brass Sink Faucets :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Standard]**
 - b. **[Anzzi; a brand of SWCorp]**
 - c. **[Aqua Design Manufacturing]**
 - d. **[Bradley Corporation]**
 - e. **[BrassTech Inc]**
 - f. **[Briggs Plumbing Products, Inc]**
 - g. **[Central Brass Company; a Pioneer Industries, Inc. brand]**
 - h. **[Chicago Faucets; Geberit Group]**
 - i. **[Danze, Inc.]**
 - j. **[Delta Faucet Company]**
 - k. **[Eljer, Inc.]**
 - l. **[Elkay]**
 - m. **[Fisher Manufacturing Co]**
 - n. **[Franke Consumer Products, Inc]**
 - o. **[Gerber Plumbing Fixtures LLC.]**
 - p. **[GROHE America, Inc]**
 - q. **[Hansgrohe USA]**
 - r. **[Hydrotek International, Inc.]**
 - s. **[Moen Incorporated]**
 - t. **[Pelican Int'l]**
 - u. **[Price Pfister, Inc]**
 - v. **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - w. **[Rohl LLC]**
 - x. **[Speakman Company]**
 - y. **[T&S Brass and Bronze Works, Inc.]**
 - z. **[Watermark Designs, Ltd.]**
 - aa. **[Wolverine Brass, Inc]**
 - bb. **[Zurn Industries, LLC]**
 - cc. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Anzzi; a brand of SWCorp]**
 - c. **[Aqua Design Manufacturing]**
 - d. **[Bradley Corporation]**
 - e. **[BrassTech Inc]**
 - f. **[Briggs Plumbing Products, Inc]**
 - g. **[Central Brass Company; a Pioneer Industries, Inc. brand]**
 - h. **[Chicago Faucets; Geberit Group]**
 - i. **[Danze, Inc.]**
 - j. **[Delta Faucet Company]**

- k. [Eljer, Inc.]
- l. [Elkay]
- m. [Fisher Manufacturing Co]
- n. [Franke Consumer Products, Inc]
- o. [Gerber Plumbing Fixtures LLC.]
- p. [GROHE America, Inc]
- q. [Hansgrohe USA]
- r. [Hydrotek International, Inc.]
- s. [Moen Incorporated]
- t. [Pelican Int'l]
- u. [Price Pfister, Inc]
- v. [ProFlo; a Ferguson Enterprises, Inc. brand]
- w. [Rohl LLC]
- x. [Speakman Company]
- y. [T&S Brass and Bronze Works, Inc.]
- z. [Watermark Designs, Ltd.]
- aa. [Wolverine Brass, Inc]
- bb. [Zurn Industries, LLC]
- cc. <Insert manufacturer's name>

2.21 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

- A. NSF Standard: Comply with NSF 61 for faucet-spout outlet materials that will be in contact with potable water.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. [AM Conservation Group, Inc.]
 - 2. [American Standard]
 - 3. [Chronomite Laboratories, Inc; a division of Morris Group International]
 - 4. [Delta Faucet Company]
 - 5. [NEOPERL, Inc.]
 - 6. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. [AM Conservation Group, Inc.]
 - 2. [American Standard]
 - 3. [Chronomite Laboratories, Inc; a division of Morris Group International]
 - 4. [Delta Faucet Company]
 - 5. [NEOPERL, Inc.]
 - 6. <Insert manufacturer's name>
- D. Description: Chrome-plated-brass, faucet-spout outlet that produces nonaerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

2.22 DISPOSERS

- A. Batch-Feed Disposers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Franke Consumer Products, Inc]**
 - b. **[InSinkErator; Emerson Electric Co., Commercial and Residential Solutions]**
 - c. **[KitchenAid; Whirlpool Corporation]**
 - d. **[Maytag; Whirlpool Corporation]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Franke Consumer Products, Inc]**
 - b. **[InSinkErator; Emerson Electric Co., Commercial and Residential Solutions]**
 - c. **[KitchenAid; Whirlpool Corporation]**
 - d. **[Maytag; Whirlpool Corporation]**
 - e. **<Insert manufacturer's name>**
- B. Continuous-Feed Disposers :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Anaheim Manufacturing, Inc.]**
 - b. **[Franke Consumer Products, Inc]**
 - c. **[InSinkErator; Emerson Electric Co., Commercial and Residential Solutions]**
 - d. **[KitchenAid; Whirlpool Corporation]**
 - e. **[Maytag; Whirlpool Corporation]**
 - f. **[WhiteRock Corp]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anaheim Manufacturing, Inc.]**
 - b. **[Franke Consumer Products, Inc]**
 - c. **[InSinkErator; Emerson Electric Co., Commercial and Residential Solutions]**
 - d. **[KitchenAid; Whirlpool Corporation]**
 - e. **[Maytag; Whirlpool Corporation]**
 - f. **[WhiteRock Corp]**
 - g. **<Insert manufacturer's name>**
- C. Standards: ASSE 1008 and UL 430, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. General: Include reset button; wall switch; corrosion-resistant chamber with jam-resistant, cutlery- or stainless steel grinder or shredder; **NPS 1-1/2 (DN 40)** outlet; quick-mounting, stainless steel sink flange; antisplash guard; and combination cover/stopper.
- E. Model: **[Not applicable][Sound-insulated chamber][Sound-insulated chamber and stainless-steel**

outer shell].

- F. Motor: 115 V ac, 1725 rpm, [1/3][1/2][3/4][1] hp with overload protection.

2.23 HOT-WATER DISPENSERS

- A. NSF Standard: Comply with NSF 61 for faucet materials that will be in contact with potable water.

- B. Gooseneck Spout with Lever-Handle, Flow-Control, Hot-Water Dispensers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Anaheim Manufacturing, Inc.]**
 - b. **[Elkay]**
 - c. **[Franke Consumer Products, Inc]**
 - d. **[InSinkErator; Emerson Electric Co., Commercial and Residential Solutions]**
 - e. **[KitchenAid; Whirlpool Corporation]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anaheim Manufacturing, Inc.]**
 - b. **[Elkay]**
 - c. **[Franke Consumer Products, Inc]**
 - d. **[InSinkErator; Emerson Electric Co., Commercial and Residential Solutions]**
 - e. **[KitchenAid; Whirlpool Corporation]**
 - f. **<Insert manufacturer's name>**

- C. Spout with Twist-Knob or Push-Button, Flow-Control, Hot-Water Dispensers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Anaheim Manufacturing, Inc.]**
 - b. **[Elkay]**
 - c. **[InSinkErator; Emerson Electric Co., Commercial and Residential Solutions]**
 - d. **[KitchenAid; Whirlpool Corporation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anaheim Manufacturing, Inc.]**
 - b. **[Elkay]**
 - c. **[InSinkErator; Emerson Electric Co., Commercial and Residential Solutions]**
 - d. **[KitchenAid; Whirlpool Corporation]**

e. <Insert manufacturer's name>

- D. Standard: ASSE 1023.
- E. General: Household-type dispenser with instant on-off control; insulated, corrosion-resistant-metal storage tank that is open to atmosphere; electric heating element; chrome-plated faucet or spout; removable strainer; thermostat control for water temperature up to **190 deg F (88 deg C)**; and thermal-overload protection.
- F. Storage Tank Capacity: **0.5 gal. (1.5 L)**.
- G. Heating Element: 750 W minimum, 115 V ac.

2.24 WATER CLOSETS

- A. Water Closets : Floor mounted, floor outlet, close coupled (gravity tank), vitreous china, [**1.6 gal./flush (6 L)/flush**][**1.28 gal./flush (5.8 L/flush)**][**1.0 gal./flush (4.5 L/flush)**].

- 1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. **[American Standard]**
 - b. **[Barclay Products Limited]**
 - c. **[Briggs Plumbing Products, Inc]**
 - d. **[Capizzi]**
 - e. **[Duravit USA, Inc]**
 - f. **[Eljer, Inc.]**
 - g. **[Gerber Plumbing Fixtures LLC.]**
 - h. **[Kohler Co]**
 - i. **[Lamosa Corp.]**
 - j. **[Mansfield Plumbing Products LLC]**
 - k. **[Pelican Int'l]**
 - l. **[St. Thomas Creations]**
 - m. **[TOTO USA, INC]**
 - n. **[Zurn Industries, LLC]**
 - o. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Barclay Products Limited]**
 - c. **[Briggs Plumbing Products, Inc]**
 - d. **[Capizzi]**
 - e. **[Duravit USA, Inc]**
 - f. **[Eljer, Inc.]**
 - g. **[Gerber Plumbing Fixtures LLC.]**
 - h. **[Kohler Co]**
 - i. **[Lamosa Corp.]**
 - j. **[Mansfield Plumbing Products LLC]**
 - k. **[Pelican Int'l]**
 - l. **[St. Thomas Creations]**

- m. **[TOTO USA, INC]**
 - n. **[Zurn Industries, LLC]**
 - o. **<Insert manufacturer's name>**
- 3. Bowl:
 - a. Standards: ASME A112.19.2/CSA B45.1, ASME A112.19.5/CSA B45.15, and ASSE 1037/ASME A112.1060/CSA B125.16.
 - b. Bowl Type: **[Siphon jet]<Insert type>**.
 - c. Height: **[Standard][Child][Handicapped/elderly]**.
 - d. Rim Contour: **[Elongated][Regular]**.
 - e. Water Consumption: **[Water saving][Low]**.
 - f. Color: **[White]<Insert color>**.
- 4. Toilet Seat: **<Insert toilet-seat designation from "Toilet Seats" Article>**.
- 5. Supply Fittings:
 - a. Standard: ASME A112.18.1/CSA B125.1.
 - b. Supply Piping: Chrome-plated-brass pipe or chrome-plated-copper tube matching water-supply piping size. Include chrome-plated wall flange.
 - c. Stop: Chrome-plated-brass, one-quarter-turn, ball-type or compression stop with inlet connection matching water-supply piping type and size.
 - 1) Operation: **[Loose key][Wheel handle]<Insert type>**.
 - d. Riser:
 - 1) Size: **[NPS 3/8 (DN 10)][NPS 1/2 (DN 15)]**.
 - 2) Material: **[Chrome-plated, soft-copper flexible tube][ASME A112.18.6/CSA 125.6, braided- or corrugated-stainless steel flexible hose]** riser.

2.25 TOILET SEATS

A. Toilet Seats :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Bemis Manufacturing Company]**
 - c. **[Centoco Manufacturing Corporation]**
 - d. **[Church Seats; Bemis Manufacturing Company]**
 - e. **[Eljer, Inc.]**
 - f. **[Jones Stephens Corp.]**
 - g. **[Olsonite Seat Co.]**
 - h. **[Pressalit Inc.]**
 - i. **[Sanderson Plumbing Products, Inc]**
 - j. **[Sperzel of Lexington]**
 - k. **[Zurn Industries, LLC]**
 - l. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[American Standard]**
 - b. **[Bemis Manufacturing Company]**
 - c. **[Centoco Manufacturing Corporation]**
 - d. **[Church Seats; Bemis Manufacturing Company]**
 - e. **[Eljer, Inc.]**
 - f. **[Jones Stephens Corp.]**
 - g. **[Olsonite Seat Co.]**
 - h. **[Pressalit Inc.]**
 - i. **[Sanderson Plumbing Products, Inc]**
 - j. **[Sperzel of Lexington]**
 - k. **[Zurn Industries, LLC]**
 - l. **<Insert manufacturer's name>**
3. Standard: IAPMO Z124.5/ANSI Z124.5.
 4. Material: Plastic.
 5. Type: **[Residential][Commercial (Standard)]**.
 6. Shape: **[Regular rim (Open front)][Regular rim (Closed front)][Elongated rim (Open front)][Elongated rim (Closed front)]**.
 7. Configuration: **[Closed][Open]** front **[with][without]** cover.
 8. Size: **[Elongated][Regular]**.
 9. Hinge Type: **[Check][Self-sustaining][Self-sustaining, check][Self-raising]**.
 10. Hinge Material: **[Noncorroding metal][Plastic]**.
 11. Seat Cover: **[Required][Not required]**.
 12. Color: **[White][Black]<Insert color>**.

2.26 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.
- C. Bidet Lavatory Bar Sink Kitchen Sink and Laundry Tray Supply Fittings:
 1. Supply Piping: Chrome-plated-brass pipe or chrome-plated-copper tube matching water-supply piping size. Include chrome-plated wall flange.
 2. Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression stop with inlet connection matching water-supply piping type and size.
 - a. Operation: **[Loose key][Wheel handle]<Insert type>**.
 3. Risers:
 - a. Size:
 - 1) **NPS 3/8 (DN 10)** for **[bidets][and][lavatories]**.
 - 2) **[NPS 3/8 (DN 10)][NPS 1/2 (DN 15)]** for **[bar sinks][kitchen sinks][and][laundry trays]**.
 - b. Material: **[Chrome-plated, soft-copper flexible tube][ASME A112.18.6/CSA B125.6, braided- or corrugated-stainless-steel flexible hose]** riser.

2.27 WASTE FITTINGS

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain:
 - 1. Grid type with **NPS 1-1/4 (DN 32)** offset tailpiece for accessible lavatories.
 - 2. Pop-up type with **NPS 1-1/4 (DN 32)** straight tailpiece as part of faucet for standard lavatories.
 - 3. Grid type with **NPS 1-1/2 (DN 40)** offset tailpiece for accessible **[bar sinks][and][kitchen sinks]**.
 - 4. Grid type with **NPS 1-1/2 (DN 40)** straight tailpiece for standard **[bar sinks][and][kitchen sinks][and for laundry trays]**.
- C. Trap:
 - 1. Size:
 - a. **[NPS 1-1/4 (DN 32)][NPS 1-1/2 by NPS 1-1/4 (DN 40 by DN 32)][NPS 1-1/2 (DN 40)]** for **[bidets][and][lavatories]**.
 - b. **NPS 1-1/2 (DN 40)** for **[bar sinks][kitchen sinks][and][laundry trays]**.
 - 2. Material:
 - a. Chrome-plated, **[two-piece, cast-brass trap and swivel elbow with 0.032-inch- (0.83-mm-) thick brass tube to wall][two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch- (0.83-mm-) thick brass tube to wall][one-piece, cast-brass trap with swivel 0.029-inch- (0.73-mm-) thick tubular brass wall bend]<Insert trap type>**; and chrome-plated-brass or -steel wall flange.
 - b. Stainless steel, two-piece trap and swivel elbow with **0.012-inch- (0.30-mm-) thick stainless steel tube to wall**; and stainless steel wall flange.
 - c. ASTM F409 **[ABS][or][PVC][one][two]-piece trap and waste to wall and wall flange**.

2.28 GROUT

- A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: **5000 psi (34.5 MPa)**, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing-fixture installation.
- B. Examine walls, floors, cabinets, and counters for suitable conditions where fixtures will be installed.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF RESIDENTIAL PLUMBING FIXTURES

- A. Install plumbing fixtures level and plumb in accordance with roughing-in drawings.
- B. Install floor-mounted water closets on closet flange attachments to drainage piping.
- C. Install counter-mounting fixtures in and attached to casework.
- D. Install pedestal lavatories on pedestals and secured to wood blocking in wall.
- E. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
 - 1. Use ball or gate valves if supply stops are not specified with fixture. Comply with valve requirements specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- F. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.
- G. Install toilet seats on water closets.
- H. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- I. Install shower flow-control fittings with specified maximum flow rates in shower arms.
- J. Install traps on fixture outlets.
 - 1. Omit trap on fixtures with integral traps.
 - 2. Omit trap on indirect wastes unless otherwise indicated.
- K. Install disposer in outlet of each sink indicated to have a disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.
- L. Install hot-water dispensers in back top surface of sink or in countertop with spout over sink.
- M. Set **[bathtubs][baths][and][shower receptors]** in leveling bed of cement grout.
- N. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible **[lavatories][and][sinks]**. Comply with requirements in Section 220719 "Plumbing Piping Insulation."
- O. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
- P. Seal joints between plumbing fixtures, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."



3.3 PIPING CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible **[lavatories][and][sinks]**. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.4 ADJUSTING

- A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

- A. After completing installation of plumbing fixtures, inspect and repair damaged finishes.
- B. Clean plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed plumbing fixtures and fittings.
- D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 41 00 00



Task	Specification	Specification Description
22 41 26 00	22 41 00 00	Residential Plumbing Fixtures
22 41 39 00	22 41 00 00	Residential Plumbing Fixtures
22 41 39 00	22 42 00 00	Commercial Plumbing Fixtures
22 41 39 00	22 45 00 00	Emergency Plumbing Fixtures



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 42 00 00 - COMMERCIAL PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Commercial lavatories.
2. Commercial showers.
3. Commercial sinks.
4. Commercial urinals.
5. Commercial water closets.
6. Commercial wash fountains.
7. Flushometer valves.
8. Toilet seats.
9. Fixture carriers.

B. Related Requirements:

1. Section 114000 "Foodservice Equipment" for NSF-compliant foodservice and handwash sinks.
2. Section 224100 "Residential Plumbing Fixtures" for residential plumbing fixtures.
3. Section 224300 "Healthcare Plumbing Fixtures" for healthcare plumbing fixtures.
4. Section 224500 "Emergency Plumbing Fixtures" for emergency plumbing fixtures.
5. Section 224600 "Security Plumbing Fixtures" for security plumbing fixtures.

1.2 DEFINITIONS

- A. FRP: Fiberglass-reinforced plastic.
- B. High-Efficiency Flush Volume: **1.28 gal. (4.8 L)** or less per flush.
- C. PMMA: Polymethyl methacrylate; also known as "acrylic."
- D. Standard-Efficiency Flush Volume: **1.6 gal. (6 L)** per flush.
- E. WaterSense Fixture: Water closet and/or flushometer valve/tank certified by the EPA to meet the WaterSense performance criteria.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Include construction details, material descriptions and thicknesses, dimensions of individual components and profiles, and finishes for plumbing fixtures.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Plans, elevations, sections, and **[mounting][attachment]** details.
2. Details of equipment assemblies, including accessories. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, location and size of each field connection, location and size of each cutout, and anchorage provisions and attachment methods. Indicate coordination requirements for adjacent and interfacing Work.
3. Diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

1. Product Data: For water consumption.
2. Plumbing Fixtures: Provide the following:
 - a. Manufacturer cut sheet indicating water consumption.
 - b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.
3. Plumbing Fixtures: Provide the following:
 - a. Manufacturer cut sheet indicating water consumption.
 - b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories and/or counter-mounted sinks.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. For lavatories and faucets.
 - a. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1) Servicing and adjustments of automatic faucets.
2. For shower valves to include in maintenance manuals.
3. For sinks and faucets to include in operation and maintenance manuals.
 - a. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1) Servicing and adjustments of automatic faucets.
4. For flushometer valves **[and electronic sensors]** to include in operation and maintenance manuals.
5. For wash fountains and components to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Faucet Washers and O-Rings: Equal to [10]<Insert number> percent of amount of each type and size installed.
 2. Faucet Cartridges and O-Rings: Equal to [5]<Insert number> percent of amount of each type and size installed.
 3. Shower Valve Washers and O-Rings: Equal to [10]<Insert number> percent of amount of each type and size installed.
 4. Shower Valve Cartridges and O-Rings: Equal to [5]<Insert number> percent of amount of each type and size installed.
 5. Waterless Urinal Trap-Seal Cartridges: Equal to [200]<Insert number> percent of amount of each type installed, but no fewer than [12]<Insert number> of each type.
 6. Waterless Urinal Trap-Seal Liquid: Equal to [1 gal. (3.8 L)]<Insert volume> for each urinal installed.
 7. Flushometer-Valve Repair Kits: Equal to [10]<Insert number> percent of amount of each type installed, but no fewer than [one][six]<Insert number> of each type.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Lavatory faucets, sink faucets, shower valves, and wash fountain spray heads and faucets intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), with requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 COMMERCIAL LAVATORIES

- A. Lavatories, Counter Mounted:
1. Lavatories, Counter Mounted - Enameled Cast Iron, Flat Rim, Flush Mount :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Commercial Enameling Company]**
 - 2) **[Kohler Co]**
 - 3) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Commercial Enameling Company]**

- 2) **[Kohler Co]**
 - 3) **<Insert manufacturer's name>**
- c. Fixture:
- 1) Standard: ASME A112.19.1/CSA B45.2.
 - 2) Type: For flush mounting with kit.
 - 3) Nominal Size: Rectangular, **[18 by 15 inches (457 by 381 mm)][20 by 18 inches (508 by 457 mm)]**.
 - 4) Faucet-Hole Punching: **[Three holes, 2-inch (51-mm)][Three holes, 4-inch (102-mm)]** centers.
 - 5) Faucet-Hole Location: Top.
 - 6) Color: **[White]<Insert color>**.
 - 7) Mounting Materials: With stainless steel ring and sealant.
- d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.
2. Lavatories, Counter Mounted - Enameled Cast Iron, Self-Rimming :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1) **[Kohler Co]**
 - 2) **[Zurn Industries, LLC]**
 - 3) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[Kohler Co]**
 - 2) **[Zurn Industries, LLC]**
 - 3) **<Insert manufacturer's name>**
- c. Fixture:
- 1) Standard: ASME A112.19.1/CSA B45.2.
 - 2) Type: Self-rimming for above-counter mounting.
 - 3) Nominal Size: Oval, **[20 by 17 inches (508 by 432 mm)]<Insert dimensions>** nominal.
 - 4) Faucet-Hole Punching: **[Single center hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]**.
 - 5) Faucet-Hole Location: Top.
 - 6) Color: **[White]<Insert color>**.
 - 7) Mounting Material: Sealant.
- d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.
3. Lavatories, Undercounter Mounted - Enameled Cast Iron :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) **[Commercial Enameling Company]**
- 2) **<Insert manufacturer's name>**

- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) **[Commercial Enameling Company]**
- 2) **<Insert manufacturer's name>**

- c. Fixture:

- 1) Standard: ASME A112.19.1/CSA B45.2.
- 2) Type: For undercounter mounting.
- 3) Nominal Size: Oval, **[20 by 17 inches (508 by 432 mm)]<Insert dimensions>** nominal.
- 4) Faucet-Hole Punching: No holes.
- 5) Faucet-Hole Location: On countertop.
- 6) Color: **[White]<Insert color>**.
- 7) Mounting Materials: Sealant and undercounter mounting kit.

- d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.

4. Lavatory, Counter Mounted - Vitreous China, Self-Rimming, Rectangular :

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- 1) **[American Standard]**
- 2) **[Gerber Plumbing Fixtures LLC.]**
- 3) **[Kohler Co]**
- 4) **[Mansfield Plumbing Products LLC]**
- 5) **[TOTO USA, INC]**
- 6) **<Insert manufacturer's name>**

- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) **[American Standard]**
- 2) **[Gerber Plumbing Fixtures LLC.]**
- 3) **[Kohler Co]**
- 4) **[Mansfield Plumbing Products LLC]**
- 5) **[TOTO USA, INC]**
- 6) **<Insert manufacturer's name>**

- c. Fixture:

- 1) Standard: ASME A112.19.2/CSA B45.1.

- 2) Type: Self-rimming for above-counter mounting.
 - 3) Nominal Size: Rectangular, [21 by 19 inches (533 by 483 mm)][24 by 20 inches (610 by 508 mm)]<Insert dimensions> nominal.
 - 4) Faucet-Hole Punching: [One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers].
 - 5) Faucet-Hole Location: Top.
 - 6) Color: [White]<Insert color>.
 - 7) Mounting Material: Sealant.
- d. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
5. Lavatory, Counter Mounted - Vitreous China, Self-Rimming, Oval or Round :
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- 1) [American Standard]
 - 2) [Briggs Plumbing Products, Inc]
 - 3) [Gerber Plumbing Fixtures LLC.]
 - 4) [Kohler Co]
 - 5) [Mansfield Plumbing Products LLC]
 - 6) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 7) [Sloan Valve Company]
 - 8) [TOTO USA, INC]
 - 9) [Zurn Industries, LLC]
 - 10) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [American Standard]
 - 2) [Briggs Plumbing Products, Inc]
 - 3) [Gerber Plumbing Fixtures LLC.]
 - 4) [Kohler Co]
 - 5) [Mansfield Plumbing Products LLC]
 - 6) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 7) [Sloan Valve Company]
 - 8) [TOTO USA, INC]
 - 9) [Zurn Industries, LLC]
 - 10) <Insert manufacturer's name>
- c. Fixture:
- 1) Standard: ASME A112.19.2/CSA B45.1.
 - 2) Type: Self-rimming for above-counter mounting.
 - 3) Nominal Size:
 - a) Oval, [19 by 17 inches (483 by 432 mm)][20 by 17 inches (508 by 432 mm)]<Insert dimensions>.
 - b) Round, [19 inches (483 mm)]<Insert dimension>.

- 4) Faucet-Hole Punching: **[One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]**.
 - 5) Faucet-Hole Location: Top.
 - 6) Color: **[White]<Insert color>**.
 - 7) Mounting Material: Sealant.
- d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.
6. Lavatories, Undercounter Mounted - Vitreous China, Oval :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1) **[American Standard]**
 - 2) **[Gerber Plumbing Fixtures LLC.]**
 - 3) **[Kohler Co]**
 - 4) **[Mansfield Plumbing Products LLC]**
 - 5) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 6) **[Sloan Valve Company]**
 - 7) **[TOTO USA, INC]**
 - 8) **[Zurn Industries, LLC]**
 - 9) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[American Standard]**
 - 2) **[Gerber Plumbing Fixtures LLC.]**
 - 3) **[Kohler Co]**
 - 4) **[Mansfield Plumbing Products LLC]**
 - 5) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 6) **[Sloan Valve Company]**
 - 7) **[TOTO USA, INC]**
 - 8) **[Zurn Industries, LLC]**
 - 9) **<Insert manufacturer's name>**
- c. Fixture:
- 1) Standard: ASME A112.19.2/CSA B45.1.
 - 2) Type: For undercounter mounting.
 - 3) Nominal Size: Oval, **[19 by 16 inches (483 by 406 mm)][22 by 14 inches (559 by 356 mm)][23 by 15 inches (584 by 381 mm)]<Insert dimensions>**.
 - 4) Faucet-Hole Punching: No holes.
 - 5) Faucet-Hole Location: On countertop.
 - 6) Color: **[White]<Insert color>**.
 - 7) Mounting Material: Sealant and undercounter mounting kit.
- d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.

B. Lavatories, Wall Mounted:

1. Lavatory, Wall Mounted - Enameled Cast Iron, Rectangular :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Standard]**
 - 2) **[Kohler Co]**
 - 3) **[Zurn Industries, LLC]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Standard]**
 - 2) **[Kohler Co]**
 - 3) **[Zurn Industries, LLC]**
 - 4) **<Insert manufacturer's name>**
 - c. Fixture:
 - 1) Standard: ASME A112.19.1/CSA B45.2.
 - 2) Type: Straight-front apron with straight back.
 - 3) Nominal Size: Rectangular, **[19 by 17 inches (483 by 432 mm)][20 by 18 inches (508 by 457 mm)]**.
 - 4) Faucet-Hole Punching: **[One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]**.
 - 5) Faucet-Hole Location: Top.
 - 6) Color: **[White]<Insert color>**.
 - 7) Mounting Material: Wall bracket.
 - d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.
 - e. Support: **[Lavatory carrier, framing affixed][Lavatory carrier, floor affixed with steel uprights]<Insert carrier>**.
 - f. Lavatory Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
2. Lavatories, Wall Mounted - Vitreous China, Rectangular with Back :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Standard]**
 - 2) **[Briggs Plumbing Products, Inc]**
 - 3) **[Gerber Plumbing Fixtures LLC.]**
 - 4) **[Kohler Co]**
 - 5) **[Mansfield Plumbing Products LLC]**
 - 6) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 7) **[Sloan Valve Company]**
 - 8) **[Zurn Industries, LLC]**

- 9) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Standard]**
 - 2) **[Briggs Plumbing Products, Inc]**
 - 3) **[Gerber Plumbing Fixtures LLC.]**
 - 4) **[Kohler Co]**
 - 5) **[Mansfield Plumbing Products LLC]**
 - 6) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 7) **[Sloan Valve Company]**
 - 8) **[Zurn Industries, LLC]**
 - 9) **<Insert manufacturer's name>**
 - c. Fixture:
 - 1) Standard: ASME A112.19.2/CSA B45.1.
 - 2) Type: For wall hanging.
 - 3) Nominal Size: Rectangular, **[18 by 16 inches (457 by 406 mm)][20 by 18 inches (508 by 457 mm)]<Insert dimensions>**.
 - 4) Faucet-Hole Punching: **[One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]**.
 - 5) Faucet-Hole Location: Top.
 - 6) Color: **[White]<Insert color>**.
 - 7) Mounting Material: Chair carrier.
 - d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.
 - e. Support: **[Lavatory carrier, framing affixed][Lavatory carrier, floor affixed with steel uprights][,][exposed arm][concealed arm]<Insert carrier>**.
 - f. Lavatory Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
3. Lavatories, Wall Mounted - Vitreous China, Rectangular with Ledge Back :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Standard]**
 - 2) **[Briggs Plumbing Products, Inc]**
 - 3) **[Gerber Plumbing Fixtures LLC.]**
 - 4) **[Kohler Co]**
 - 5) **[Mansfield Plumbing Products LLC]**
 - 6) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 7) **[Sloan Valve Company]**
 - 8) **[TOTO USA, INC]**
 - 9) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) [American Standard]
 - 2) [Briggs Plumbing Products, Inc]
 - 3) [Gerber Plumbing Fixtures LLC.]
 - 4) [Kohler Co]
 - 5) [Mansfield Plumbing Products LLC]
 - 6) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 7) [Sloan Valve Company]
 - 8) [TOTO USA, INC]
 - 9) <Insert manufacturer's name>
- c. Fixture:
- 1) Standard: ASME A112.19.2/CSA B45.1.
 - 2) Type: For wall hanging.
 - 3) Nominal Size: Rectangular, [19 by 17 inches (483 by 432 mm)][20 by 18 inches (508 by 457 mm)]<Insert dimensions>.
 - 4) Faucet-Hole Punching: [One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers].
 - 5) Faucet-Hole Location: Top.
 - 6) Color: [White]<Insert color>.
 - 7) Mounting Material: Chair carrier.
- d. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
- e. Support: [Lavatory carrier, framing affixed][Lavatory carrier, floor affixed with steel uprights][,][exposed arm][concealed arm]<Insert carrier>.
- f. Lavatory Mounting Height: [Standard][Juvenile][Accessible in accordance with ICC A117.1].
4. Lavatories, Wall Mounted - Vitreous China, Rectangular, Wheelchair :
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- 1) [American Standard]
 - 2) [Gerber Plumbing Fixtures LLC.]
 - 3) [Kohler Co]
 - 4) [Zurn Industries, LLC]
 - 5) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [American Standard]
 - 2) [Gerber Plumbing Fixtures LLC.]
 - 3) [Kohler Co]
 - 4) [Zurn Industries, LLC]
 - 5) <Insert manufacturer's name>
- c. Fixture:
- 1) Standard: ASME A112.19.2/CSA B45.1.

- 2) Type: Wheelchair.
 - 3) Nominal Size: Rectangular, **27 by 20 inches (686 by 508 mm)**.
 - 4) Faucet-Hole Punching: **[One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102 mm) centers][Three holes, 5- to 6-inch (127- to 150-mm) centers]**.
 - 5) Faucet-Hole Location: Top.
 - 6) Color: **[White]<Insert color>**.
 - 7) Mounting: For concealed-arm carrier.
- d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.
 - e. Support: **[Lavatory carrier, floor affixed with steel uprights][,][exposed-arm][concealed-arm]<Insert carrier>**.
 - f. Lavatory Mounting Height: **[Juvenile][Accessible in accordance with ICC A117.1]**.
5. Lavatories, Wall Mounted - Vitreous China, Corner Type :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Standard]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Standard]**
 - 2) **<Insert manufacturer's name>**
 - c. Fixture:
 - 1) Standard: ASME A112.19.2/CSA B45.1.
 - 2) Type: Three-sided-front apron with three-sided back.
 - 3) Nominal Size: Corner, **16 by 16 inches (406 by 406 mm)**.
 - 4) Faucet-Hole Punching: **[One hole][Three holes, 2-inch (51-mm) centers]**.
 - 5) Faucet-Hole Location: Back wall.
 - 6) Color: **[White]<Insert color>**.
 - 7) Mounting Materials: Wall brackets.
 - d. Faucet: Manufacturer's standard; factory installed.
 - e. Support: **[Lavatory carrier, framing affixed][Lavatory carrier, floor affixed with steel uprights]<Insert carrier>**.
 - f. Lavatory Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
6. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with Integral Ramp Basin(s) :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) **[Trueform Concrete, LLC]**
 - 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[Trueform Concrete, LLC]**
 - 2) **<Insert manufacturer's name>**
- c. Basin(s) and Countertop:
- 1) Standards: CSA B45.8/IAPMO Z403 and ICC A117.1.
 - 2) Type: Straight front and side aprons with straight back.
 - 3) Number of Stations: **[One][Two][Three][Four]**.
 - 4) Overall Countertop Size: **[30 by 21 by 5 inches (762 by 533 by 127 mm) (per station)]<Insert dimension>**.
 - 5) Basin I.D.: **[20 by 13 by 5 inches (508 by 330 by 127mm)][18 by 12 by 5 inches (457 by 305 by 127 mm)][14 by 10 by 5 inches (356 by 254 by 127 mm)]**.
 - 6) Faucet-Hole Punching (per Station): **[Zero holes][One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]<Insert hole pattern>**.
 - 7) Faucet-Hole Location: **[Top][Wall mount]**.
 - 8) Drain Type: Slot drain
 - 9) Color: **[White linen][Concrete][Charcoal][Limestone][Graphite][Pewter][Dusk][Taupe]<Insert color>**.
 - 10) Mounting: Concrete wall brackets.
- d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.
- e. Waste Fittings:
- 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Connection: **1-1/4-inch (32-mm)** fine thread tailpiece.
 - 3) Finish: **[Polished chrome][Brushed nickel][Oil-rubbed bronze]**.
- f. Support: Manufacturer's standard product.
- g. Lavatory Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
7. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with Integral Rectangular Basin(s) :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1) **[Trueform Concrete, LLC]**
 - 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) [Trueform Concrete, LLC]
 - 2) <Insert manufacturer's name>
 - c. Basin(s) and Countertop:
 - 1) Standards: CSA B45.8/IAPMO Z403 and ICC A117.1.
 - 2) Type: Straight front and side aprons with straight back.
 - 3) Number of Stations: [One][Two][Three][Four].
 - 4) Overall Countertop Size: [30 by 21 by 5 inches (762 by 533 by 127 mm) (per station)]<Insert dimension>.
 - 5) Basin I.D.: 20 by 13 by 5 inches (508 by 330 by 127 mm).
 - 6) Faucet-Hole Punching (per Station): [Zero holes][One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]<Insert hole pattern>.
 - 7) Faucet-Hole Location: [Top][Wall mount].
 - 8) Drain Type: 1-1/4-inch (32-mm) grid drain assembly.
 - 9) Color: [White linen][Concrete][Charcoal][Limestone][Graphite][Pewter][Dusk][Taupe]<Insert color>.
 - 10) Mounting: Concrete wall brackets.
 - d. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
 - e. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Type: 1-1/4-inch (32-mm) grid drain assembly.
 - 3) Finish: [Polished chrome][Brushed nickel][Oil-rubbed bronze].
 - f. Support: Manufacturer's standard product.
 - g. Lavatory Mounting Height: [Standard][Juvenile][Accessible in accordance with ICC A117.1].
8. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with Integral Half-Trough Basin(s) :
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Trueform Concrete, LLC]
 - 2) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Trueform Concrete, LLC]
 - 2) <Insert manufacturer's name>
 - c. Fixture:
 - 1) Standards: CSA B45.8/IAPMO Z403 and ICC A117.1.
 - 2) Type: Straight front and side aprons with straight back.
 - 3) Number of Stations: [One][Two][Three][Four].
 - 4) Overall Countertop Size: [30 by 21 by 5 inches (762 by 533 by 127 mm) (per

- station)]<Insert dimension>.
- 5) Basin I.D.: [20 by 13 by 5-1/2 inches (508 by 330 by 140 mm)][16 by 14 by 5-1/2 inches (406 by 356 by 140 mm)].
- 6) Faucet-Hole Punching (per Station): [Zero holes][One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]<Insert hole pattern>.
- 7) Faucet-Hole Location: [Top][Wall mount].
- 8) Drain Type: 1-1/4-inch (32-mm) grid drain assembly.
- 9) Color: [White linen][Concrete][Charcoal][Limestone][Graphite][Pewter][Dusk][Taupe]<Insert color>.
- 10) Mounting: Concrete wall brackets.
- d. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
- e. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Type: 1-1/4-inch (32-mm) grid drain assembly.
 - 3) Finish: [Polished chrome][Brushed nickel][Oil-rubbed bronze].
- f. Support: Manufacturer's standard product.
- g. Lavatory Mounting Height: [Standard][Juvenile][Accessible in accordance with ICC A117.1].
9. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with Single Integral Ramp Basin, Two Station :
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Trueform Concrete, LLC]
 - 2) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Trueform Concrete, LLC]
 - 2) <Insert manufacturer's name>
 - c. Fixture:
 - 1) Standards: CSA B45.8/IAPMO Z403 and ICC A117.1.
 - 2) Type: Straight front and side aprons with straight back.
 - 3) Overall Countertop Size: [60 by 21 by 5 inches (1525 by 533 by 127 mm)][72 by 21 by 5 inches (1829 by 533 by 127 mm)]<Insert dimension>.
 - 4) Basin I.D.: [48 by 13 by 5 inches (1220 by 330 by 127 mm)][50 by 12 by 5 inches (1270 by 305 by 127 mm)][50 by 13 by 5 inches (1270 by 330 by 127 mm)][60 by 13 by 5 inches (1525 by 330 by 127 mm)].
 - 5) Faucet-Hole Punching (per Station): [Zero holes][One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]<Insert hole pattern>.
 - 6) Faucet-Hole Location: [Top][Wall mount].

- 7) Drain Type: Slot drain.
 - 8) Color: **[White linen][Concrete][Charcoal][Limestone][Graphite][Pewter][Dusk][Taupe]<Insert color>**.
 - 9) Mounting Material: Concrete wall brackets.
- d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.
- e. Waste Fittings:
- 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Type: **1-1/2-inch (38-mm)** slip joint connection.
 - 3) Finish: **[Polished chrome][Brushed nickel][Oil-rubbed bronze]**.
- f. Support: Manufacturer's standard product.
- g. Lavatory Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
10. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with Single Integral Ramp Basin, Three Station :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1) **[Trueform Concrete, LLC]**
 - 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[Trueform Concrete, LLC]**
 - 2) **<Insert manufacturer's name>**
- c. Fixture:
- 1) Standards: CSA B45.8/IAPMO Z403 and ICC A117.1.
 - 2) Type: Straight front and side aprons with straight back.
 - 3) Overall Countertop Size: **[72 by 21 by 5 inches (1829 by 533 by 127 mm)][90 by 21 by 5 inches (2286 by 533 by 127 mm)]<Insert dimension>**.
 - 4) Basin I.D.: **[60 by 13 by 5 inches (1524 by 330 by 127 mm)][72 by 13 by 5 inches (1829 by 330 by 127 mm)][80 by 12 by 5 inches (2032 by 305 by 127 mm)][84 by 12 by 5 inches (2134 by 305 by 127 mm)]**.
 - 5) Faucet-Hole Punching (per Station): **[Zero holes][One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]<Insert hole pattern>**.
 - 6) Faucet-Hole Location: **[Top][Wall mount]**.
 - 7) Drain Type: Slot drain.
 - 8) Color: **[White linen][Concrete][Charcoal][Limestone][Graphite][Pewter][Dusk][Taupe]<Insert color>**.
 - 9) Mounting Material: Concrete wall brackets.
- d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually**



- Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.**
- e. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Type: **1-1/2-inch (38-mm)** slip joint connection.
 - 3) Finish: **[Polished chrome][Brushed nickel][Oil-rubbed bronze]**.
 - f. Support: Manufacturer's standard product.
 - g. Lavatory Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
11. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with Single Integral Ramp Basin, Four Station :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Trueform Concrete, LLC]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Trueform Concrete, LLC]**
 - 2) **<Insert manufacturer's name>**
 - c. Fixture:
 - 1) Standards: CSA B45.8/IAPMO Z403 and ICC A117.1.
 - 2) Type: Straight front and side aprons with straight back.
 - 3) Overall Countertop Size: **[106 by 21 by 5 inches (2692 by 533 by 127 mm)][120 by 21 by 5 inches (3048 by 533 by 127 mm)]<Insert dimension>**.
 - 4) Basin I.D.: **[96 by 12 by 5 inches (2438 by 305 by 127 mm)][110 by 12 by 5 inches (2794 by 305 by 127 mm)]**.
 - 5) Faucet-Hole Punching (per Station): **[Zero holes][One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]<Insert hole pattern>**.
 - 6) Faucet-Hole Location: **[Top][Wall mount]**.
 - 7) Drain Type: Slot drain.
 - 8) Color: **[White linen][Concrete][Charcoal][Limestone][Graphite][Pewter][Dusk][Taupe]<Insert color>**.
 - 9) Mounting Material: Concrete wall brackets.
 - d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.
 - e. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Type: **1-1/2-inch (38-mm)** slip joint connection.
 - 3) Finish: **[Polished chrome][Brushed nickel][Oil-rubbed bronze]**.

- f. Support: Manufacturer's standard product.
- g. Lavatory Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1].**

C. Lavatories, Freestanding:

1. Lavatories, Freestanding - Precast GFRC, Rectangular Countertop Deck with Integral Ramp Basin, Two Station :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Trueform Concrete, LLC]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Trueform Concrete, LLC]**
 - 2) **<Insert manufacturer's name>**
 - c. Fixture:
 - 1) Standards: CSA B45.8/IAPMO Z403 and ICC A117.1.
 - 2) Type: Straight front and side aprons with straight back.
 - 3) Overall Countertop size: **[68 by 22 by 5 inches (1727 by 559 by 127 mm)]<Insert dimension>**.
 - 4) Basin I.D.: **[48 by 13 by 5 inches (1219 by 330 by 127 mm)][50 by 12 by 5 inches (1270 by 305 by 127 mm)][50 by 13 by 5 inches (1270 by 330 by 127 mm)][60 by 13 by 5 inches (1524 by 330 by 127 mm)].**
 - 5) Faucet-Hole Punching (per Station): **[Zero holes][One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]<Insert hole pattern>**.
 - 6) Faucet-Hole Location: **[Top][Wall mount]**.
 - 7) Drain Type: Slot drain.
 - 8) Color: **[White linen][Concrete][Charcoal][Limestone][Graphite][Pewter][Dusk][Taupe]<Insert color>**.
 - 9) Mounting Material: Concrete sink steel base.
 - d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.
 - e. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Type: **1-1/2-inch (38-mm)** slip joint connection.
 - 3) Finish: **[Polished chrome][Brushed nickel][Oil-rubbed bronze]**.
 - f. Support: Concrete sink steel base.
 - g. Lavatory Height: Accessible in accordance with ICC A117.1.
2. Lavatories, Freestanding - Precast GFRC, Rectangular Countertop Deck with Integral Ramp Basin, Three Station :

- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Trueform Concrete, LLC]
 - 2) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Trueform Concrete, LLC]
 - 2) <Insert manufacturer's name>
 - c. Fixture:
 - 1) Standards: CSA B45.8/IAPMO Z403 and ICC A117.1.
 - 2) Type: Straight front and side aprons with straight back.
 - 3) Overall Countertop Size: [72 by 22 by 5 inches (1829 by 559 by 127 mm)][84 by 22 by 5 inches (2134 by 559 by 127 mm)][98 by 22 by 5 inches (2489 by 559 by 127 mm)]<Insert dimension>.
 - 4) Basin I.D.: [60 by 13 by 5 inches (1524 by 330 by 127 mm)][72 by 13 by 5 inches (1829 by 330 by 127 mm)][80 by 12 by 5 inches (2032 by 305 by 127 mm)][84 by 12 by 5 inches (2134 by 305 by 127 mm)].
 - 5) Faucet-Hole Punching (per Station): [Zero holes][One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]<Insert hole pattern>.
 - 6) Faucet-Hole Location: [Top][Wall mount].
 - 7) Drain Type: Slot drain.
 - 8) Color: [White linen][Concrete][Charcoal][Limestone][Graphite][Pewter][Dusk][Taupe]<Insert color>.
 - 9) Mounting Material: Concrete sink steel base.
 - d. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
 - e. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Type: 1-1/2-inch (38-mm) slip joint connection.
 - 3) Finish: [Polished chrome][Brushed nickel][Oil-rubbed bronze].
 - f. Support: Manufacturer's concrete sink steel base.
 - g. Lavatory Height: Accessible in accordance with ICC A117.1.
3. Lavatories, Freestanding - Precast GFRC, Rectangular Countertop Deck with Integral Ramp Basin, Four Station :
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Trueform Concrete, LLC]

- 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Trueform Concrete, LLC]**
 - 2) **<Insert manufacturer's name>**
 - c. Fixture:
 - 1) Standards: CSA B45.8/IAPMO Z403 and ICC A117.1.
 - 2) Type: Straight front and side aprons with straight back.
 - 3) Overall Countertop Size: **[107 by 22 by 5 inches (2718 by 559 by 127 mm)][128 by 22 by 5 inches (3251 by 559 by 127 mm)]<Insert dimension>**.
 - 4) Basin I.D.: **[96 by 12 by 5 inches (2438 by 305 by 127 mm)][110 by 12 by 5 inches (2794 by 305 by 127 mm)]**.
 - 5) Faucet-Hole Punching (per Station): **[Zero holes][One hole][Three holes, 2-inch (51-mm) centers][Three holes, 4-inch (102-mm) centers]<Insert hole pattern>**.
 - 6) Faucet-Hole Location: **[Top][Wall mount]**.
 - 7) Drain Type: Slot drain.
 - 8) Color: **[White linen][Concrete][Charcoal][Limestone][Graphite][Pewter][Dusk][Taupe]<Insert color>**.
 - 9) Mounting Material: Concrete sink steel base.
 - d. Faucet: **<Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>**.
 - e. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Type: **1-1/2-inch (38-mm)** slip joint connection.
 - 3) Finish: **[Polished chrome][Brushed nickel][Oil-rubbed bronze]**.
 - f. Support: Manufacturer's concrete sink steel base.
 - g. Lavatory Height: Accessible in accordance with ICC A117.1.
- D. Lavatory Systems:
1. Lavatory Systems - Single or Multiple Stations :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Bradley Corporation]**
 - 3) **[D13 Group]**
 - 4) **[Sloan Valve Company]**
 - 5) **[Splash Lab (The)]**
 - 6) **[Willoughby Industries, Inc.]**
 - 7) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) **[Acorn Engineering Company; a Division of Morris Group International]**
- 2) **[Bradley Corporation]**
- 3) **[D13 Group]**
- 4) **[Sloan Valve Company]**
- 5) **[Splash Lab (The)]**
- 6) **[Willoughby Industries, Inc.]**
- 7) **<Insert manufacturer's name>**

c. Source Limitations: Obtain lavatory systems from single source from single manufacturer.

d. Standards:

- 1) ASME A112.18.1/CSA B125.1.
- 2) CSA B45.5/IAPMO Z124.
- 3) NSF 61.
- 4) NSF 372.
- 5) Uniform Plumbing Code, International Plumbing Code, and GREENGUARD Certified.

e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

f. Bowl(s) and Counter:

- 1) Material: Solid-surface or natural quartz surface.
- 2) Height to Rim: **[Standard][Accessible in accordance with ICC A117.1]<Insert height>**.
- 3) Color or Finish: **[Not applicable]<Insert if required>**.
- 4) Access Panel: **16-1/8-inch (410-mm)** access panel.
- 5) Number of Bowls or User Stations: **[One][Two][Three][Four]<Insert number>**.
- 6) Bowl Shape: **[Trough][Oval][Round][Square][Rectangular]<Insert shape>**.
- 7) Drain: Grid with **NPS 1-1/2 (DN 40)** tailpiece, each bowl.

g. Pedestal: **[Not required][Required, with access panel]**.

h. Faucets:

- 1) Type: Manufacturer's standard, chrome-plated solid brass, each bowl/station.
- 2) Control: **[Manual, push-button][Hardwired, control-voltage, sensor-actuated][Battery-powered, sensor-actuated]<Insert type>** actuation with **[pressure-balancing][thermostatic]** mixing valve with check stops for each bowl or user station.

i. Mixer Point-of-Use:

- 1) Material: Solid bimetal (bronze, brass, stainless steel).
- 2) Security: Hot limit stop set to a maximum of **109.4 deg F (43 deg C)**.
- 3) Set: Screwdriver adjustment temperature dial with scale: Cold-hot.
- 4) Operation: Electronic "no-touch" hardwired powered.
- 5) Power: 120 V ac.

j. High-Speed, Warm-Air Hand Dryer:

- 1) Dryer Mounting: **[Surface mounted][, with low-profile design]**.
- 2) Operation: Electronic-sensor activated with operation time of **[10 to 20]<Insert**

- number(s)**> seconds.
- 3) Cover Material and Finish: **[Chrome-plated steel]**<Insert material and finish>.
 - 4) Electrical Requirements: **[115 V, 13 A, 1500 W][115 V, 15 A, 1725 W][115 V, 20 A, 2300 W][208-240 V, 9-10 A, 1900-2300 W]**<Insert electrical requirements>.
- k. Liquid-Soap Dispensers: **[Hardwired, sensor actuated][Battery powered, sensor actuated][Not required]**, for each bowl or user station.
 - l. Mounting: **[Manufacturer's wall-mounting bracket][and/or][commercial floor-mounted carrier]**<Insert type>.
 - m. Supply Fittings:
 - 1) Piping: **NPS 1/2 (DN 15)** copper tubing, each bowl.
 - 2) Valves: Shutoff valve on each supply.
 - 3) Supply Piping: From wall.
 - n. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Trap and Drain Piping: **NPS 1-1/2 (DN 40)**, each bowl.
- E. Lavatory Faucets, Manually Operated :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[CHG; Component Hardware Group, Inc.]**
 - c. **[Chicago Faucets; Geberit Group]**
 - d. **[Delta Faucet Company]**
 - e. **[Elkay]**
 - f. **[Gerber Plumbing Fixtures LLC.]**
 - g. **[Just Manufacturing]**
 - h. **[Kohler Co]**
 - i. **[Krowne]**
 - j. **[Moen Incorporated]**
 - k. **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - l. **[Speakman Company]**
 - m. **[T&S Brass and Bronze Works, Inc.]**
 - n. **[Whitehall Manufacturing; a division of Morris Group International]**
 - o. **[Zurn Industries, LLC]**
 - p. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[CHG; Component Hardware Group, Inc.]**
 - c. **[Chicago Faucets; Geberit Group]**
 - d. **[Delta Faucet Company]**
 - e. **[Elkay]**
 - f. **[Gerber Plumbing Fixtures LLC.]**
 - g. **[Just Manufacturing]**
 - h. **[Kohler Co]**

- i. [Krowne]
 - j. [Moen Incorporated]
 - k. [ProFlo; a Ferguson Enterprises, Inc. brand]
 - l. [Speakman Company]
 - m. [T&S Brass and Bronze Works, Inc.]
 - n. [Whitehall Manufacturing; a division of Morris Group International]
 - o. [Zurn Industries, LLC]
 - p. <Insert manufacturer's name>
3. Standard: ASME A112.18.1/CSA B125.1.
 4. Operation Type: [Single control, mixing][Single control, nonmixing][Two handle, mixing], [Commercial][General duty].
 5. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
 6. Body Type: [Centerset][Widespread][Single hole]<Insert type>.
 7. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
 8. Finish: [Polished chrome plate]<Insert finish>.
 9. Maximum Flow Rate: [0.5 gpm (1.9 L/min.)]<Insert value>.
 10. Maximum Flow: [0.25 gal. (0.95 L)]<Insert value> per metering cycle.
 11. Mounting Type: [Deck, exposed][Deck, concealed][Back/wall, exposed][Back/wall, concealed].
 12. Valve Handle(s): [Single lever][Knob][Knob, nonmetallic][Cross, three arm][Cross, four arm][Wrist blade, 4 inches (102 mm)][Elbow, 6 inches (150 mm)][Push button]<Insert type>.
 13. Spout: [Rigid][Swing][Rigid, gooseneck][Swivel, gooseneck] type.
 14. Spout Outlet: [Aerator][Laminar flow][Spray]<Insert type>.
 15. Operation: [Compression, manual][Noncompression, manual].
 16. Drain: [Not part of faucet]<Insert type>.

F. Lavatory Faucets, Automatically Operated :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Advanced Modern Technologies Corporation - AMTC]
 - b. [American Standard]
 - c. [Bradley Corporation]
 - d. [Chicago Faucets; Geberit Group]
 - e. [Delta Faucet Company]
 - f. [Elkay]
 - g. [Hydrotek International, Inc.]
 - h. [Just Manufacturing]
 - i. [Kohler Co]
 - j. [Krowne]
 - k. [Moen Incorporated]
 - l. [ProFlo; a Ferguson Enterprises, Inc. brand]
 - m. [Sloan Valve Company]
 - n. [Speakman Company]
 - o. [Stern Engineering Ltd.]
 - p. [T&S Brass and Bronze Works, Inc.]
 - q. [TOTO USA, INC]
 - r. [Whitehall Manufacturing; a division of Morris Group International]
 - s. [Zurn Industries, LLC]

- t. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Advanced Modern Technologies Corporation - AMTC]
 - b. [American Standard]
 - c. [Bradley Corporation]
 - d. [Chicago Faucets; Geberit Group]
 - e. [Delta Faucet Company]
 - f. [Elkay]
 - g. [Hydrotek International, Inc.]
 - h. [Just Manufacturing]
 - i. [Kohler Co]
 - j. [Krowne]
 - k. [Moen Incorporated]
 - l. [ProFlo; a Ferguson Enterprises, Inc. brand]
 - m. [Sloan Valve Company]
 - n. [Speakman Company]
 - o. [Stern Engineering Ltd.]
 - p. [T&S Brass and Bronze Works, Inc.]
 - q. [TOTO USA, INC]
 - r. [Whitehall Manufacturing; a division of Morris Group International]
 - s. [Zurn Industries, LLC]
 - t. <Insert manufacturer's name>
 3. Standards: ASME A112.18.1/CSA B125.1 and UL 1951.
 4. Operation Type: [Battery powered][Hardwired] electronic sensor operated, [mixing][nonmixing].
 5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 6. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
 7. Body Type: [Single hole]<Insert type>.
 8. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
 9. Finish: [Polished chrome plate]<Insert finish>.
 10. Maximum Flow Rate: [0.5 gpm (1.9 L/min.)]<Insert value>.
 11. Mounting Type: [Deck, concealed][Back/wall, concealed]<Insert type>.
 12. Spout: [Rigid][Swing][Rigid, gooseneck][Swivel, gooseneck] type.
 13. Spout Outlet: [Aerator][Laminar flow][Spray]<Insert type>.
 14. Drain: [Not part of faucet]<Insert type>.
- G. Lavatory Supply Fittings:
 1. NSF Standards: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.
 2. Standard: ASME A112.18.1/CSA B125.1.
 3. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless steel wall flange.
 4. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
 5. Operation: [Loose key][Wheel handle]<Insert type>.
 - a. Risers Size: [NPS 3/8 (DN 10)][NPS 1/2 (DN 15)].

- b. Risers Material: **[Chrome-plated, rigid-copper-pipe and brass straight or offset tailpieces][Chrome-plated, soft-copper flexible tube][ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel, flexible hose].**

H. Lavatory Waste Fittings:

- 1. Standard: ASME A112.18.2/CSA B125.2.
- 2. Drain: Grid type with **NPS 1-1/4 (DN 32)** offset and straight tailpiece.
- 3. Trap:
 - a. Size: **[NPS 1-1/2 by NPS 1-1/4 (DN 40 by DN 32)][NPS 1-1/4 (DN 32)].**
 - b. Material:
 - 1) Chrome-plated, **[two-piece, cast-brass trap and swivel elbow with 0.032-inch- (0.83-mm-) thick brass tube to wall][two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch- (0.83-mm-) thick brass tube to wall][one-piece, cast-brass trap with swivel 0.029-inch- (0.73-mm-) thick tubular brass wall bend]<Insert trap type>;** and chrome-plated, brass or steel wall flange.
 - 2) Stainless steel, two-piece trap and swivel elbow with **0.012-inch (0.30-mm-)** thick stainless steel tube to wall, and stainless steel wall flange.

2.3 COMMERCIAL SHOWERS

A. Showers, Individual:

- 1. Showers, Individual - Cast Polymer :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[International Marble Industries]**
 - 2) **[Mincey Marble]**
 - 3) **[MPL Co.]**
 - 4) **[Winglts]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[International Marble Industries]**
 - 2) **[Mincey Marble]**
 - 3) **[MPL Co.]**
 - 4) **[Winglts]**
 - 5) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain cast-polymer showers from single manufacturer.
 - d. Description: Molded and pre-cut cast-polymer (cultured marble) shower surround panels and accessories consisting of various choices of panel styles, textures, colors, and configurations, assembled in place in accordance with approved Shop Drawings.
 - e. Fire Hazard Classification:

- 1) Standard, non-Class A.
 - 2) Class A, tested to ASTM E84[; **with ASTM E84 compliance certified by an NRTL**].
- f. Accessories Material: Cast polymer, except where stainless steel is indicated in "Accessories" Subparagraph.
- g. Accessories:
- 1) Ledge.
 - 2) Panel trim strips.
 - 3) Seam cover.
 - 4) Soap dish[- **wall mount with drainage ridges**].
 - 5) Corner soap dish[- **smooth**][- **drainage ridges**][- **stainless steel grid**][- **stainless steel slotted plate**].
 - 6) Shampoo shelf.
 - 7) Accessory shelf.
 - 8) Footrest[- **chrome, wall mount**][- **chrome, corner mount**][- **black, corner mount**].
 - 9) Threshold.
 - 10) Door jamb.
 - 11) Niche.
 - 12) Nook.
 - 13) Window sill.
- h. Shower Basin:
- 1) Coordinating cast-polymer (cultured marble) shower basin.
 - 2) Standard: CSA B45.5/IAPMO Z124.
 - 3) Type: [**Standard**][**Accessible in accordance with ICC A117.1**].
 - 4) Nominal Size and Shape: See Drawings.
 - 5) Color: [**White**]<Insert color>.
- a) Outlet: Drain with [**NPS 2 (DN 50)**]<Insert pipe size> outlet[; **lip drain outside shower in accordance with ADA-ABA**].
- i. See Drawings for specific panels[, **shower basin**,] and accessory configurations.
2. Showers, Individual - FRP, One Piece without Top :
- a. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
- 1) [**Florestone Products Co., Inc.**]
 - 2) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert **manufacturer's name; product name or designation**> or comparable product by one of the following:
- 1) [**Florestone Products Co., Inc.**]
 - 2) <Insert manufacturer's name>
- c. Source Limitations: Obtain FRP showers without top from single source from single manufacturer.
- d. Description: FRP shower enclosure with valve and receptor[**and appurtenances**].

- e. Standard: CSA B45.5/IAPMO Z124.
 - f. Style: **[Standard][Accessible in accordance with ICC A117]**.
 - g. Shower Head and Shower Valve: **<Insert shower head and shower valve designation from "Shower Valve Assemblies" Paragraph>**.
 - h. Shower Nominal Size and Shape: **[30 by 30 inches (762 by 762 mm) square][32 by 32 inches (813 by 813 mm) square][34 by 34 inches (865 by 865 mm) square][36 by 36 inches (914 by 914 mm) square][48 by 36 inches (1219 by 914 mm) rectangular][60 by 36 inches (1524 by 914 mm) rectangular][36 inches (914 mm) neo-corner (two walls)][36 inches (914 mm) neo-corner (four walls)][38 inches (965 mm) neo-corner (two walls)][38 inches (965 mm) neo-corner (four walls)][42 inches (1067 mm) neo-corner (two walls)][42 inches (1067 mm) neo-corner (four walls)]<Insert dimensions>**.
 - i. Color: **[White]<Insert color>**.
 - j. Outlet: Drain with **[NPS 2 (DN 50)]<Insert pipe size>** outlet.
 - k. Shower Rod and Curtain: **[Not required][Required]**.
 - l. Grab Bar: **[ASTM F446, mounted on support area back wall][Not required]**.
3. Showers, Individual - FRP, Sectional without Top :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[E. L. Mustee & Sons, Inc]**
 - 2) **[Florestone Products Co., Inc.]**
 - 3) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[E. L. Mustee & Sons, Inc]**
 - 2) **[Florestone Products Co., Inc.]**
 - 3) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain FRP showers without top from single source from single manufacturer.
 - d. Description: FRP shower enclosure with valve and receptor **[and appurtenances]**.
 - e. Standard: CSA B45.5/IAPMO Z124.
 - f. Style: **[Standard][Accessible in accordance with ICC A117.1]**.
 - g. Shower Head and Shower Valve: **<Insert shower head and shower valve designation from "Shower Valve Assemblies" Paragraph>**.
 - h. Shower Nominal Size and Shape: **[30 by 30 inches (762 by 762 mm) square][32 by 32 inches (813 by 813 mm) square][34 by 34 inches (865 by 865 mm) square][36 by 36 inches (915 by 915 mm) square][48 by 36 inches (1219 by 914 mm) rectangular][60 by 36 inches (1524 by 915 mm) rectangular][36 inches (915 mm) neo-corner (two walls)][36 inches (914 mm) neo-corner (four walls)][38 inches (965 mm) neo-corner (two walls)][38 inches (965 mm) neo-corner (four walls)][42 inches (1067 mm) neo-corner (two walls)][42 inches (1067 mm) neo-corner (four walls)]<Insert dimensions>**.
 - i. Color: **[White]<Insert color>**.
 - j. Outlet: Drain with **[NPS 2 (DN 50)]<Insert pipe size>** outlet.
 - k. Shower Rod and Curtain: **[Not required][Required]**.
 - l. Grab Bar: **[ASTM F446, mounted on support area back wall][Not required]**.

4. Showers, Individual - PMMA :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Aqua Bath Company, Inc.]**
 - 2) **[Aquarius Bathware; a Praxis Company]**
 - 3) **[Clarion Bathware]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Aqua Bath Company, Inc.]**
 - 2) **[Aquarius Bathware; a Praxis Company]**
 - 3) **[Clarion Bathware]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain PMMA showers from single source from single manufacturer.
 - d. Description: PMMA shower enclosure with valve and receptor **[and appurtenances]**.
 - e. Type: **[One-piece][Sectional]**.
 - f. Standard: CSA B45.5/IAPMO Z124.
 - g. Style: **[Standard][Accessible in accordance with ICC A117.1]**.
 - h. Shower Head and Shower Valve: **<Insert shower head and shower valve designation from "Shower Valve Assemblies" Paragraph>**.
 - i. Shower Nominal Size and Shape: **[30 by 30 inches (762 by 762 mm) square][32 by 32 inches (813 by 813 mm) square][34 by 34 inches (865 by 865 mm) square][36 by 36 inches (914 by 914 mm) square][48 by 36 inches (1219 by 914 mm) rectangular][60 by 36 inches (1524 by 914 mm) rectangular][36 inches (914 mm) neo-corner (two walls)][36 inches (914 mm) neo-corner (four walls)][38 inches (965 mm) neo-corner (two walls)][38 inches (965 mm) neo-corner (four walls)][42 inches (1067 mm) neo-corner (two walls)][42 inches (1067 mm) neo-corner (four walls)]<Insert dimensions>..**
 - j. Color: **[White]<Insert color>**.
 - k. Outlet: Drain with **[NPS 2 (DN 50)]<Insert pipe size>** outlet.
 - l. Shower Rod and Curtain: **[Not required][Required]**.
 - m. Grab Bar: **[ASTM F446, mounted on support area back wall][Not required]**.
5. Showers, Individual - Cabinet :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Comfort Designs Bathware]**
 - 2) **[E. L. Mustee & Sons, Inc]**
 - 3) **[Stern-Williams Products, LLC.]**
 - 4) **[Willoughby Industries, Inc.]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of

the following:

- 1) **[Comfort Designs Bathware]**
 - 2) **[E. L. Mustee & Sons, Inc]**
 - 3) **[Stern-Williams Products, LLC.]**
 - 4) **[Willoughby Industries, Inc.]**
 - 5) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain cabinet showers from single source from single manufacturer.
- d. Description: Factory-fabricated[, **accessible**] cabinet shower, with valve and receptor.
- e. Nominal Size: **[30 by 30 inches (762 by 762 mm)][32 by 32 inches (813 by 813 mm)][36 by 36 inches (914 by 914 mm)][36 by 39 inches (914 by 990 mm)][45 by 39 inches (1145 by 990 mm)]<Insert dimensions>**.
- f. Material: **[Steel][Stainless steel][Composite][Plastic]**.
- g. Access: **[Front][Corner][Front and rear]** access.
- h. Color: **[Not applicable]<Insert color>**.
- i. Accessibility Options: Grab bar and bench.
- j. Shower Head and Shower Valve: **[Manufacturer's standard fitting assembly]<Insert shower head and shower valve designation from "Shower Valve Assemblies" Paragraph>**.
- k. Supplies: **NPS 1/2 (DN 15)** copper tubing[**with ball or gate valves**].
- l. Drain: Grid, **NPS 2 (DN 50)**.

B. Shower Valve Assemblies:

1. Shower Valve Assemblies - Single-Handle, Pressure-Balanced Mixing Valve with Head :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Standard]**
 - 2) **[Chicago Faucets; Geberit Group]**
 - 3) **[Kohler Co]**
 - 4) **[Moen Incorporated]**
 - 5) **[POWERS; A Watts Water Technologies Company]**
 - 6) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 7) **[Speakman Company]**
 - 8) **[Symmons Industries, Inc]**
 - 9) **[Zurn Industries, LLC]**
 - 10) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Standard]**
 - 2) **[Chicago Faucets; Geberit Group]**
 - 3) **[Kohler Co]**
 - 4) **[Moen Incorporated]**
 - 5) **[POWERS; A Watts Water Technologies Company]**
 - 6) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 7) **[Speakman Company]**
 - 8) **[Symmons Industries, Inc]**

- 9) [Zurn Industries, LLC]
 - 10) <Insert manufacturer's name>
- c. Source Limitations: Obtain shower heads and shower valves from single source from single manufacturer.
 - d. Description: Single-handle, [accessible], pressure-balance mixing valve with hot- and cold-water indicators; [diverting valve] check stops; and [hose with handheld shower head][hose with handheld shower head on sliding rod] shower head.
 - e. Shower Valve:
 - 1) Standards:
 - a) ASME A112.18.1/CSA B125.1.
 - b) ASSE 1016/ASME A112.1016/CSA B125.16.
 - 2) Body Material: Solid brass.
 - 3) Finish: [Polished chrome plate]<Insert finish>.
 - 4) Mounting: [Concealed][Exposed].
 - 5) Operation: Single-handle, [push-pull][or][twist or rotate][or][metering] control.
 - 6) Antiscald Device: [Integral with mixing valve][Separate unit][Not required].
 - 7) Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
 - f. Supply Connections: **NPS 1/2 (DN 15)**.
 - g. Shower Head:
 - 1) Standard: ASME A112.18.1/CSA B125.1.
 - 2) Type: [Ball joint with arm and flange][Without ball joint, but with arm and flange][Ball joint and head integral with mounting flange][Integral with mounting flange]<Insert type>.
 - 3) EPA WaterSense: Required.
 - 4) Shower Head Maximum Flow Rate: [1.5 gpm (5.7 L/min.)][1.75 gpm (6.6 L/min.)][2.0 gpm (7.6 L/min.)][2.5 gpm (9.5 L/min.)].
 - 5) Shower Head Material: Metallic with chrome-plated finish.
 - 6) Spray Pattern: [Adjustable][Fixed].
 - 7) Integral Volume Control: [Not required][Required].
 - 8) Temperature Indicator: [Integral with shower valve][Not required].
2. Shower Valve Assemblies - Single-Handle, Thermostatic Mixing Valve with Head :
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Lawler Manufacturing Company, Inc]
 - 2) [POWERS; A Watts Water Technologies Company]
 - 3) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Lawler Manufacturing Company, Inc]
 - 2) [POWERS; A Watts Water Technologies Company]
 - 3) <Insert manufacturer's name>

- c. Source Limitations: Obtain shower heads and shower valves from single source from single manufacturer.
 - d. Description: Single-handle, **[accessible]**thermostatic mixing valve with hot- and cold-water indicators; **[diverting valve]**check stops; and **[hose with handheld shower head][hose with handheld shower head on sliding rod]** shower head.
 - e. Shower Valve:
 - 1) Standards:
 - a) ASME A112.18.1/CSA B125.1.
 - b) ASSE 1016/ASME A112.1016/CSA B125.16.
 - 2) Body Material: Solid brass.
 - 3) Finish: **[Polished chrome plate]<Insert finish>**.
 - 4) Mounting: **[Concealed][Exposed]**.
 - 5) Operation: Single-handle, **[push-pull][or][twist or rotate]** control.
 - 6) Antiscald Device: **[Integral with mixing valve][Separate unit][Not required]**.
 - 7) Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
 - f. Supply Connections: **NPS 1/2 (DN 15)**.
 - g. Shower Head:
 - 1) Standard: ASME A112.18.1/CSA B125.1.
 - 2) Type: **[Ball joint with arm and flange][Without ball joint, but with arm and flange][Ball joint and head integral with mounting flange][Integral with mounting flange]<Insert type>**.
 - 3) EPA WaterSense: Required.
 - 4) Shower Head Maximum Flow Rate: **[1.5 gpm (5.7 L/min.)][1.75 gpm (6.6 L/min.)][2.0 gpm (7.6 L/min.)][2.5 gpm (9.5 L/min.)]**.
 - 5) Shower Head Material: Metallic with chrome-plated finish.
 - 6) Spray Pattern: **[Adjustable][Fixed]**.
 - 7) Integral Volume Control: **[Not required][Required]**.
 - 8) Temperature Indicator: **[Integral with valve][Not required]**.
3. Shower Valve Assemblies - Single-Handle, Thermostatic/Pressure-Balancing Mixing Valve with Head :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Chicago Faucets; Geberit Group]**
 - 2) **[Lawler Manufacturing Company, Inc]**
 - 3) **[POWERS; A Watts Water Technologies Company]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Chicago Faucets; Geberit Group]**
 - 2) **[Lawler Manufacturing Company, Inc]**
 - 3) **[POWERS; A Watts Water Technologies Company]**

4) <Insert manufacturer's name>

- c. Source Limitations: Obtain shower heads and shower valves from single source from single manufacturer.
- d. Description: Single-handle, **[accessible]**, thermostatic/pressure-balancing mixing valve with hot- and cold-water indicators; **[diverting valve]** check stops; and **[hose with handheld shower head][hose with handheld shower head on sliding rod]** shower head.
- e. Shower Valve:

1) Standards:

- a) ASME A112.18.1/CSA B125.1.
- b) ASSE 1016/ASME A112.1016/CSA B125.16.

2) Body Material: Solid brass.

3) Finish: **[Polished chrome plate]**<Insert finish>.

4) Mounting: **[Concealed][Exposed]**.

5) Operation: Single-handle, **[push-pull][or][twist or rotate]** control.

6) Antiscald Device: **[Integral with mixing valve][Separate unit][Not required]**.

7) Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

f. Supply Connections: **NPS 1/2 (DN 15)**.

g. Shower Head:

1) Standard: ASME A112.18.1/CSA B125.1.

2) Type: **[Ball joint with arm and flange][Without ball joint, but with arm and flange][Ball joint and head integral with mounting flange][Integral with mounting flange]**<Insert type>.

3) EPA WaterSense: Required.

4) Shower Head Maximum Flow Rate: **[1.5 gpm (5.7 L/min.)][1.75 gpm (6.6 L/min.)][2.0 gpm (7.6 L/min.)][2.5 gpm (9.5 L/min.)]**.

5) Shower Head Material: Metallic with chrome-plated finish.

6) Spray Pattern: **[Adjustable][Fixed]**.

7) Integral Volume Control: **[Not required][Required]**.

8) Temperature Indicator: **[Integral with valve][Not required]**.

C. Shower Basins:

1. Shower Basins - Cast Polymer :

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1) **[International Marble Industries]**

2) **[Mincey Marble]**

3) **[MPL Co.]**

4) **[Winglts]**

5) <Insert manufacturer's name>

- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) **[International Marble Industries]**
 - 2) **[Mincey Marble]**
 - 3) **[MPL Co.]**
 - 4) **[Winglts]**
 - 5) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain shower basins from single source from single manufacturer.
 - d. Description: Cast-polymer base for built-up-type shower fixture.
 - e. Standard: CSA B45.5/IAPMO Z124.
 - f. Type: **[Standard][Accessible in accordance with ICC A117.1].**
 - g. Nominal Size and Shape: **[30 by 30 inches (762 by 762 mm) square][32 by 32 inches (813 by 813 mm) square][34 by 34 inches (865 by 865 mm) square][36 by 36 inches (914 by 914 mm) square][42 by 34 to 36 inches (1067 by 865 to 914 mm) rectangular][48 by 34 to 36 inches (1219 by 865 to 914 mm) rectangular][36 inches (914 mm) neo-corner][42 inches (1067 mm) neo-corner]<Insert dimensions>.**
 - h. Color: **[White]<Insert color>.**
 - i. Outlet: Drain with **[NPS 2 (DN 50)]<Insert pipe size>** outlet[; lip drain outside shower in accordance with ADA-ABA].
2. Shower Basins - FRP :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[E. L. Mustee & Sons, Inc]**
 - 2) **[Sterling; a Kohler Company]**
 - 3) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[E. L. Mustee & Sons, Inc]**
 - 2) **[Sterling; a Kohler Company]**
 - 3) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain shower basins from single source from single manufacturer.
 - d. Description: FRP base for built-up-type shower fixture.
 - e. Standard: CSA B45.5/IAPMO Z124.
 - f. Type: **[Standard][Accessible in accordance with ICC A117.1].**
 - g. Nominal Size and Shape: **[30 by 30 inches (762 by 762 mm) square][32 by 32 inches (813 by 813 mm) square][34 by 34 inches (865 by 865 mm) square][36 by 36 inches (914 by 914 mm) square][42 by 34 to 36 inches (1067 by 864 to 914 mm) rectangular][48 by 34 to 36 inches (1219 by 864 to 914 mm) rectangular][36 inches (914 mm) neo-corner][42 inches (1067 mm) neo-corner]<Insert dimensions>.**
 - h. Color: **[White]<Insert color>.**
 - i. Outlet: Drain with **[NPS 2 (DN 50)]<Insert pipe size>** outlet[; lip drain outside shower in accordance with ADA-ABA].
3. Shower Basins - PMMA :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) [Florestone Products Co., Inc.]
- 2) [Jason International, Inc]
- 3) [MAAX]
- 4) [Royal Baths Manufacturing Co]
- 5) [Sterling; a Kohler Company]
- 6) [Swan Surfaces LLC (Swanstone)]
- 7) <Insert manufacturer's name>

- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) [Florestone Products Co., Inc.]
- 2) [Jason International, Inc]
- 3) [MAAX]
- 4) [Royal Baths Manufacturing Co]
- 5) [Sterling; a Kohler Company]
- 6) [Swan Surfaces LLC (Swanstone)]
- 7) <Insert manufacturer's name>

- c. Source Limitations: Obtain shower basins from single source from single manufacturer.
- d. Description: PMMA base for built-up-type shower fixture.
- e. Standard: CSA B45.5/IAPMO Z124.
- f. Type: [Standard][Accessible in accordance with ICC A117.1].
- g. Nominal Size and Shape: [30 by 30 inches (762 by 762 mm) square][32 by 32 inches (813 by 813 mm) square][36 by 36 inches (914 by 914 mm) square][42 by 34 to 36 inches (1067 by 865 to 914 mm) rectangular][48 by 34 to 36 inches (1219 by 865 to 914 mm) rectangular][36 inches (914 mm) neo-corner][42 inches (1067 mm) neo-corner]<Insert dimensions>.
- h. Color: [White]<Insert color>.
- i. Outlet: Drain with [NPS 2 (DN 50)]<Insert pipe size> outlet[; lip drain outside shower in accordance with ADA-ABA].

4. Shower Basins - Molded Stone :

- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) [American Bath Factory]
- 2) [Fiat Products]
- 3) [International Marble Industries]
- 4) <Insert manufacturer's name>

- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) [American Bath Factory]
- 2) [Fiat Products]
- 3) [International Marble Industries]
- 4) <Insert manufacturer's name>

- c. Source Limitations: Obtain shower basins from single source from single manufacturer.
 - d. Description: Molded-stone base for built-up-type shower fixture.
 - e. Standard: CSA B45.8/IAPMO Z403.
 - f. Type: **[Standard][Accessible in accordance with ICC A117.1].**
 - g. Nominal Size and Shape: **[30 by 30 inches (762 by 762 mm) square][32 by 32 inches (813 by 813 mm) square][36 by 36 inches (914 by 914 mm) square][42 by 34 to 36 inches (1067 by 865 to 914 mm) rectangular][48 by 34 to 36 inches (1219 by 864 to 915 mm) rectangular][36 inches (914 mm) neo-corner][42 inches (1067 mm) neo-corner]<Insert dimensions>.**
 - h. Color: **[White]<Insert color>.**
 - i. Outlet: Drain with **[NPS 2 (DN 50)]<Insert pipe size> outlet[; lip drain outside shower in accordance with ADA-ABA].**
5. Shower Basins - Precast Terrazzo :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Fiat Products]**
 - 2) **[Florestone Products Co., Inc.]**
 - 3) **[Stern-Williams Products, LLC.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Fiat Products]**
 - 2) **[Florestone Products Co., Inc.]**
 - 3) **[Stern-Williams Products, LLC.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain shower basins from single source from single manufacturer.
 - d. Description: Precast-terrazzo base for built-up-type shower fixture.
 - e. Standard: CSA B45.8/IAPMO Z403.
 - f. Type: **[Standard][Accessible in accordance with ICC A117.1].**
 - g. Nominal Size and Shape: **[30 by 30 inches (762 by 762 mm) square][32 by 32 inches (813 by 813 mm) square][36 by 36 inches (914 by 914 mm) square][42 by 34 to 36 inches (1067 by 865 to 914 mm) rectangular][48 by 34 to 36 inches (1219 by 865 to 914 mm) rectangular][36 inches (914 mm) neo-corner][42 inches (1067 mm) neo-corner]<Insert dimensions>.**
 - h. Color: **[White]<Insert color>.**
 - i. Outlet: Drain with **[NPS 2 (DN 50)]<Insert pipe size> outlet[; lip drain outside shower in accordance with ADA-ABA].**
6. Shower Basins - Solid Surface :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[American Standard]**

- 2) [Comfort Designs Bathware]
- 3) [inpro Corporation]
- 4) [International Marble Industries]
- 5) [Swan Surfaces LLC (Swanstone)]
- 6) [Tower Industries, Inc.]
- 7) [Willoughby Industries, Inc.]
- 8) <Insert manufacturer's name>

- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) [American Standard]
- 2) [Comfort Designs Bathware]
- 3) [inpro Corporation]
- 4) [International Marble Industries]
- 5) [Swan Surfaces LLC (Swanstone)]
- 6) [Tower Industries, Inc.]
- 7) [Willoughby Industries, Inc.]
- 8) <Insert manufacturer's name>

- c. Source Limitations: Obtain shower basins from single source from single manufacturer.
- d. Description: Solid-surface base for built-up-type shower fixture.
- e. Standard: CSA B45.5/IAPMO Z124.
- f. Type: [Standard][**Accessible in accordance with ICC A117.1**].
- g. Nominal Size and Shape: [30 by 30 inches (762 by 762 mm) square][32 by 32 inches (813 by 813 mm) square][36 by 36 inches (914 by 914 mm) square][42 by 34 to 36 inches (1067 by 865 to 914 mm) rectangular][48 by 34 to 36 inches (1219 by 865 to 914 mm) rectangular][36 inches (914 mm) neo-corner][42 inches (1067 mm) neo-corner]<Insert dimensions>.
- h. Color: [White]<Insert color>.
- i. Outlet: Drain with [NPS 2 (DN 50)]<Insert pipe size> outlet; lip drain outside shower in accordance with ADA-ABA].

D. Showers, Group:

1. Showers, Group - Column :

- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) [Acorn Engineering Company; a Division of Morris Group International]
- 2) [Bradley Corporation]
- 3) [Willoughby Industries, Inc.]
- 4) <Insert manufacturer's name>

- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) [Acorn Engineering Company; a Division of Morris Group International]
- 2) [Bradley Corporation]
- 3) [Willoughby Industries, Inc.]
- 4) <Insert manufacturer's name>

- c. Source Limitations: Obtain showers from single source from single manufacturer.
 - d. Description: Stainless steel, column shower fixture with individual nozzles.
 - e. Standards:
 - 1) ASME A112.18.1/CSA B125.1.
 - 2) ASSE 1016/ASME A112.1016/CSA B125.16.
 - f. Metal Nominal Thickness: **[0.050 inch (1.3 mm) minimum][0.063 inch (1.6 mm)]**.
 - g. Number of Shower Nozzles: **[Two][Three][Four][Five][Six]**.
 - h. Height to Nozzles: **[66 inches (1675 mm)][72 inches (1829 mm)][78 inches (1981 mm)]<Insert dimension>**.
 - i. Control:
 - 1) **[Thermostatic][Pressure-balance]** mixing valve with hot and cold-water operation.
 - 2) Thermostatic mixing valve with individual, tempered-water supply and push-button operation.
 - j. Shower-Arm, Flow-Control Fitting: **[Not required][1.5 gpm (5.7 L/min.)][2.0 gpm (7.6 L/min.)][2.5 gpm (9.5 L/min.)]** for each shower head.
 - k. EPA WaterSense: Required.
 - l. Liquid Soap Dispenser: **[Not required][Required]** for each shower head.
 - m. Soap Dish: **[Not required][Required]** for each shower head.
 - n. Mounting: Floor flange.
 - o. Supplies: **[NPS 3/4 (DN 20)][NPS 1 (DN 25)]** copper tubing with shutoff valve from **[bottom][top]**.
 - p. Shroud: **[Not required][Stainless steel of size to cover supplies and vent piping]**.
 - q. Drain Fitting: **[NPS 3 (DN 80)][NPS 4 (DN 100)]** outlet with **NPS 2 (DN 50)** vent, integral with base of column.
2. Showers, Group - Wall Mounted :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Bradley Corporation]**
 - 2) **[Willoughby Industries, Inc.]**
 - 3) **[Zurn Industries, LLC]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Bradley Corporation]**
 - 2) **[Willoughby Industries, Inc.]**
 - 3) **[Zurn Industries, LLC]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain showers from single source from single manufacturer.
 - d. Description: Stainless steel, wall-mounted, surface-enclosure shower fixture with individual nozzles.
 - e. Standards:

- 1) ASME A112.18.1/CSA B125.1.
 - 2) ASSE 1016/ASME A112.1016/CSA B125.16.
- f. Metal Nominal Thickness: **[0.050 inch (1.3 mm) minimum][0.063 inch (1.6 mm)]**.
 - g. Number of Shower Nozzles: **[Two][Three]**.
 - h. Height to Nozzles: **[66 inches (1675 mm)][72 inches (1830 mm)]<Insert dimension>**.
 - i. Control:
 - 1) **[Thermostatic][Pressure-balance]** valve with individual hot- and cold-water mixing-valve operation.
 - 2) Thermostatic valve with individual, tempered-water supply and push-button operation.
 - j. Flow-Control Fitting: **[Not required][1.5 gpm (5.7 L/min.)][2.0 gpm (7.6 L/min.)][2.5 gpm (9.5 L/min.)]** for each shower head.
 - k. EPA WaterSense: Required.
 - l. Liquid Soap Dispenser: **[Not required][Required]** for each shower head.
 - m. Soap Dish: **[Not required][Required]** for each shower head.
 - n. Mounting: Wall bracket.
 - o. Supplies: **NPS 3/4 (DN 20)** copper tubing with valves.

E. Showers, Outdoor:

1. Showers, Outdoor - Plastic :

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[ShowerTower Inc]**
 - 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[ShowerTower Inc]**
 - 2) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain showers from single source from single manufacturer.
- d. Description: Freestanding, plastic group-shower fixture.
- e. Number of Shower Stations: **[One][Two][Three][Four]<Insert number up to six>** with individual, self-closing control valve(s).
- f. Nozzles: With adjustable spray pattern; fixed, on column.
- g. Control: Push button and timer.
- h. Maximum Flow: **2.5 gpm (9.5 L/min.)** for each shower head.
- i. Number of Foot-Wash Stations: **[One][Two]<Insert number>** with individual, self-closing control valve(s).
- j. Hose Bibb: **[Not][One]** required.
- k. Control-Valve Mounting Height: **[50 inches (1270 mm)][48 inches (1219 mm)]**.
- l. Material: Cast-filled-polymer plastic.
- m. Color: **[Gray]<Insert color>**.
- n. Internal Piping: Factory installed.
- o. Mounting: Base flange with bolt holes.

2. Showers, Outdoor - Steel :

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Bradley Corporation]**
 - 2) **[Most Dependable Fountains, Inc.]**
 - 3) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Bradley Corporation]**
 - 2) **[Most Dependable Fountains, Inc.]**
 - 3) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain showers from single source from single manufacturer.
- d. Description: Freestanding, steel, group-shower fixture.
- e. Number of Shower Stations: **[Four or more]<Insert value>** with individual, self-closing control valve(s).
- f. Nozzles: Fixed, on column.
- g. Control: Push button and timer.
- h. Maximum Flow: **2.5 gpm (9.5 L/min.)** for each shower head.
- i. Flow-Control Fitting: **[Not required][1.5 gpm (5.7 L/min.)][2.0 gpm (7.6 L/min.)][2.5 gpm (9.5 L/min.)]** for each shower head.
- j. EPA WaterSense: Required.
- k. Number of Foot-Wash Stations: **[Not required][One][Two]** with individual, self-closing control valve(s).
- l. Material: **[Powder-coated steel][Stainless steel]**.
- m. Color: **[Blue]<Insert color>**.
- n. Internal Piping: Factory installed.
- o. Mounting: Base flange with bolt holes.

F. Grout:

- 1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- 2. Characteristics: Nonshrink; recommended for interior and exterior applications.
- 3. Design Mix: **5000 psi (34.5 MPa)**, 28-day compressive strength.
- 4. Packaging: Premixed and factory packaged.

2.4 COMMERCIAL SINKS**A. Service Sinks, Floor Mounted:****1. Service Sinks, Floor Mounted - Terrazzo :**

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Fiat Products]**
 - 3) **[Florestone Products Co., Inc.]**
 - 4) **[Stern-Williams Products, LLC.]**
 - 5) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Fiat Products]**
 - 3) **[Florestone Products Co., Inc.]**
 - 4) **[Stern-Williams Products, LLC.]**
 - 5) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain sinks from single source from single manufacturer.
- d. Fixture:
- 1) Material: Marble chips cast in portland cement to produce a compressive strength of not less than **3000 psi (20.7 MPa)**, seven days after casting.
 - 2) Shape: **[Square][Rectangular][Five sided][Radial front]<Insert shape>**.
 - 3) Nominal Size: **[24 by 24 inches (610 by 610 mm)][30 by 30 inches (762 by 762 mm)][24 by 36 inches (610 by 914 mm)][32 by 32 inches (813 by 813 mm)][36 by 36 inches (914 by 914 mm)]<Insert dimensions>**.
 - 4) Height: **[6 inches (150 mm)][10 inches (254 mm)][12 inches (305 mm)][12 inches (305 mm) with dropped front]<Insert dimensions>**.
 - 5) Tiling Flange: **[Not required][On one side][On two sides][On three sides]**.
 - 6) Rim Guard: On **[front][all]** top surfaces.
 - 7) Color: **[Not applicable]<Insert color>**.
 - 8) Drain: Grid with **[NPS 2 (DN 50)][NPS 3 (DN 80)]** outlet.
- e. Mounting: On floor and flush to wall.
- f. Faucet: **<Insert service sink faucet designation from "Sink Faucets, Manually Operated" Paragraph>**.
2. Service Sinks, Floor Mounted - Plastic :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 2) **[Zurn Industries, LLC]**
 - 3) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 2) **[Zurn Industries, LLC]**
 - 3) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain sinks from single source from single manufacturer.

- d. Fixture:
 - 1) Standard: CSA B45.5/IAPMO Z124.
 - 2) Material: **[Molded polymer]<Insert material>**.
 - 3) Nominal Size: **[24 by 36 by 10 inches (610 by 914 mm by 255 mm)][36 by 36 by 10 inches (914 by 914 by 255 mm)]<Insert dimensions>**.
 - 4) Rim Guard: On **[front][all]** top surfaces.
 - 5) Color: **[Not applicable]<Insert color>**.
 - 6) Drain: Grid with **[NPS 2 (DN 50)][NPS 3 (DN 80)]** outlet.
 - e. Mounting: On floor and flush to wall.
 - f. Faucet: **<Insert service sink faucet designation from "Sink Faucets, Manually Operated" Paragraph>**.
3. Service Sinks, Floor Mounted - Molded Stone :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Fiat Products]**
 - 2) **[Florestone Products Co., Inc.]**
 - 3) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Fiat Products]**
 - 2) **[Florestone Products Co., Inc.]**
 - 3) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sinks from single source from single manufacturer.
 - d. Fixture:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Shape: **[Square][Rectangular]<Insert shape>**.
 - 3) Nominal Size: **[24 by 24 inches (610 by 610 mm)][24 by 36 inches (610 by 914 mm)]<Insert dimensions>**.
 - 4) Height: **[10 inches (255 mm)]<Insert dimensions>**.
 - 5) Rim Guard: On **[front][all]** top surfaces.
 - 6) Color: **[Not applicable]<Insert color>**.
 - 7) Drain: Grid with **[NPS 2 (DN 50)][NPS 3 (DN 80)]** outlet.
 - e. Mounting: On floor and flush to wall.
 - f. Faucet: **<Insert service sink faucet designation from "Sink Faucets, Manually Operated" Paragraph>**.
4. Service Sinks, Floor Mounted - Enameled Cast Iron :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) [Commercial Enameling Company]
 - 2) [Zurn Industries, LLC]
 - 3) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [Commercial Enameling Company]
 - 2) [Zurn Industries, LLC]
 - 3) <Insert manufacturer's name>
- c. Source Limitations: Obtain sinks from single source from single manufacturer.
- d. Fixture:
- 1) Standard: ASME A112.19.1/CSA B45.2.
 - 2) Style: With front apron and raised back.
 - 3) Nominal Size: **28 by 28 inches (710 by 710 mm)**.
 - 4) Color: White.
 - 5) Drain: Grid with [NPS 2 (DN 50)][NPS 3 (DN 80)] outlet.
 - 6) Rim Guard: Coated wire.
- e. Faucet: <Insert service sink faucet designation from "Sink Faucets, Manually Operated" Subparagraph>.
- B. Service Sinks, Trap Standard Mounted:
1. Service Sinks, Trap Standard Mounted - Enameled Cast Iron :
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [American Standard]
 - 2) [Commercial Enameling Company]
 - 3) [Kohler Co]
 - 4) [Zurn Industries, LLC]
 - 5) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [American Standard]
 - 2) [Commercial Enameling Company]
 - 3) [Kohler Co]
 - 4) [Zurn Industries, LLC]
 - 5) <Insert manufacturer's name>
 - c. Source Limitations: Obtain sinks from single source from single manufacturer.
 - d. Fixture:
 - 1) Standard: ASME A112.19.1/CSA B45.2.
 - 2) Type: Service sink with back.
 - 3) Back: [Two faucet holes][Plain].

- 4) Nominal Size: [22 by 18 inches (559 by 457 mm)][24 by 20 inches (610 by 508 mm)].
- 5) Color: White.
- 6) Mounting: [NPS 2 (DN 50)][NPS 3 (DN 80)] P-trap standard with grid strainer inlet, cleanout, and floor flange.
- 7) Rim Guard: On front and sides.
- e. Faucet: <Insert service sink faucet designation from "Sink Faucets, Manually Operated" Paragraph>.
- f. Support: [Sink carrier]<Insert carrier>.

C. Kitchen/Utility Sinks:

1. Kitchen/Utility Sinks, Counter Mounted - Stainless Steel :

- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Advance Tabco]
 - 2) [Amerisink Inc.]
 - 3) [Eagle Group]
 - 4) [Elkay]
 - 5) [Just Manufacturing]
 - 6) [Krowne]
 - 7) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Advance Tabco]
 - 2) [Amerisink Inc.]
 - 3) [Eagle Group]
 - 4) [Elkay]
 - 5) [Just Manufacturing]
 - 6) [Krowne]
 - 7) <Insert manufacturer's name>
- c. Source Limitations: Obtain sinks from single source from single manufacturer.
- d. Fixture:
 - 1) Standard: ASME A112.19.3/CSA B45.4.
 - 2) Type: Stainless steel, self-rimming, sound-deadened unit [less ledge back][with ledge back].
 - 3) Number of Compartments: [One][Two][Three].
 - 4) Overall Dimensions: <Insert dimensions>.
 - 5) Material: 18 gauge, Type 304 stainless steel.
 - 6) Compartment:
 - a) Dimensions: <Insert dimensions>.
 - b) Drain: [Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain][Grid with NPS 2 (DN 50) tailpiece and twist drain][NPS 1-1/2 (DN 40) tailpiece with stopper]<Insert drain>.

- c) Drain Location: **[Centered in compartment][Near back of compartment][Near left side of compartment][Near right side of compartment]<Insert location>**.
 - d) Depth: **[Standard][Accessible in accordance with ICC A117.1]**.
 - 7) Each Compartment:
 - a) Dimensions: **<Insert dimensions>**.
 - b) Drains: **[Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain][Grid with NPS 2 (DN 50) tailpiece and twist drain][NPS 1-1/2 (DN 40) tailpiece with stopper]<Insert drain>**.
 - c) Drain Location: **[Centered in compartment][Near back of compartment]<Insert location>**.
 - d) Depth: **[Standard][Accessible in accordance with ICC A117.1]**.
 - e. Faucet(s): **<Insert sink faucet designation from "Sink Faucets, Manually Operated" or "Sink Faucets, Automatically Operated" Subparagraph>**.
 - 1) Number Required: **[One][Two]**.
 - 2) Mounting: On ledge.
 - f. Supply Fittings:
 - 1) Standard: ASME A112.18.1/CSA B125.1.
 - 2) Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
 - a) Operation: **[Loose key][Wheel handle]<Insert type>**.
 - b) Risers: **NPS 1/2 (DN 15), [chrome-plated, rigid-copper pipe][chrome-plated, soft-copper flexible tube][ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel flexible hose]**.
 - g. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Trap(s) Size: **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]**.
 - 3) Trap(s) Material:
 - a) Chrome-plated, **[two-piece, cast-brass trap and swivel elbow with 17-gauge brass tube to wall][two-piece, cast-brass trap and ground-joint swivel elbow with 17-gauge brass tube to wall]<Insert trap type>**; and chrome-plated brass or steel wall flange.
 - b) Stainless steel, two-piece trap and swivel elbow with **0.012-inch- (0.30-mm-)** thick stainless steel tube to wall; and stainless steel wall flange.
 - 4) Continuous Waste:
 - a) Size: **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]**.
 - b) Material: Chrome-plated, 17-gauge brass tube.
 - h. Mounting: On counter with sealant.
2. Kitchen/Utility Sinks, Freestanding - Stainless Steel :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) **[Advance Tabco]**
 - 2) **[AERO Manufacturing Company]**
 - 3) **[Amtekco Industries, Inc; a Wasserstrom Company]**
 - 4) **[Eagle Group]**
 - 5) **[Elkay]**
 - 6) **[Griffin Products, Inc.]**
 - 7) **[Just Manufacturing]**
 - 8) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[Advance Tabco]**
 - 2) **[AERO Manufacturing Company]**
 - 3) **[Amtekco Industries, Inc; a Wasserstrom Company]**
 - 4) **[Eagle Group]**
 - 5) **[Elkay]**
 - 6) **[Griffin Products, Inc.]**
 - 7) **[Just Manufacturing]**
 - 8) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain sinks from single source from single manufacturer.
- d. Fixture:
- 1) Standards:
 - a) ASME A112.19.3/CSA B45.4.
 - b) NSF 2.
 - 2) Type: Stainless steel, freestanding, sound-deadened unit with backsplash.
 - 3) Number of Compartments: **[One][Two][Three][Four]**.
 - 4) Overall Dimensions: **<Insert dimensions>**.
 - 5) Material: **[14][16]** gauge, Type 304 stainless steel.
 - 6) Compartment:
 - a) Dimensions: **<Insert dimensions>**.
 - b) Drain: **[Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain][Grid with NPS 2 (DN 50) tailpiece and twist drain][NPS 1-1/2 (DN 40) tailpiece with stopper]<Insert drain>**.
 - c) Drain Location: **[Centered in compartment][Near back of compartment][Near left side of compartment][Near right side of compartment]<Insert location>**.
 - 7) Each Compartment:
 - a) Dimensions: **<Insert dimensions>**.
 - b) Drains: **[Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain][Grid with NPS 2 (DN 50) tailpiece and twist drain][NPS 1-1/2 (DN 40) tailpiece with stopper]<Insert drain>**.
 - c) Drain Location: **[Centered in compartment][Near back of compartment]<Insert location>**.

- 8) Integral Drainboard(s): **[Not required][Both][Left][Right]** side(s).
 - a) Dimensions Each: **[Not applicable]<Insert dimensions>**.
- e. Legs and Feet: Stainless steel tubing legs with adjustable bullet feet.
- f. Faucet(s): **<Insert sink faucet designation from "Sink Faucets, Manually Operated" or "Sink Faucets, Automatically Operated" Paragraph>**.
 - 1) Number Required: **[One][Two]**.
 - 2) Mounting: On backsplash.
- g. Supply Fittings:
 - 1) Standard: ASME A112.18.1/CSA B125.1.
 - 2) Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
 - a) Operation: **[Loose key][Wheel handle]<Insert type>**.
 - b) Risers: **NPS 1/2 (DN 15), [chrome-plated, rigid-copper pipe][chrome-plated, soft-copper flexible tube][ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel flexible hose]**.
- h. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Trap(s) Size: **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]**.
 - 3) Trap(s) Material:
 - a) Chrome-plated, **[two-piece, cast-brass trap and swivel elbow with 17-gauge brass tube to wall][two-piece, cast-brass trap and ground-joint swivel elbow with 17-gauge brass tube to wall]<Insert trap type>**; and chrome-plated brass or steel wall flange.
 - b) Stainless steel, two-piece trap and swivel elbow with **0.012-inch- (0.30-mm-)** thick stainless steel tube to wall; and stainless steel wall flange.
 - 4) Continuous Waste:
 - a) Size: **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]**.
 - b) Material: Chrome-plated, 17-gauge brass tube.

D. Handwash Sinks:

1. Handwash Sinks - Stainless Steel :

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Advance Tabco]**
 - 2) **[AERO Manufacturing Company]**
 - 3) **[Amtekco Industries, Inc; a Wasserstrom Company]**
 - 4) **[Eagle Group]**
 - 5) **[Elkay]**
 - 6) **[Griffin Products, Inc.]**
 - 7) **[Just Manufacturing]**



- 8) [Krowne]
- 9) [Sloan Valve Company]
- 10) <Insert manufacturer's name>

b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) [Advance Tabco]
- 2) [AERO Manufacturing Company]
- 3) [Amtekco Industries, Inc; a Wasserstrom Company]
- 4) [Eagle Group]
- 5) [Elkay]
- 6) [Griffin Products, Inc.]
- 7) [Just Manufacturing]
- 8) [Krowne]
- 9) [Sloan Valve Company]
- 10) <Insert manufacturer's name>

c. Source Limitations: Obtain sinks from single source from single manufacturer.

d. Fixture:

- 1) Standards:
 - a) ASME A112.19.3/CSA B45.4.
 - b) NSF 61.
- 2) Type: [Wall-mounted][Pedestal-base] stainless steel basin with radius corners, back for faucet, and support brackets.
- 3) Overall Dimensions: [17 by 16 by 5 inches (430 by 406 by 127 mm)]<Insert dimensions>.
- 4) Material: [18 gauge][20 gauge]<Insert gauge>, Type 304 stainless steel.

e. Faucet: <Insert sink faucet designation from "Sink Faucets, Manually Operated" or "Sink Faucets, Automatically Operated" Paragraph>.

f. Supply Fittings: Comply with requirements in "Sink Supply Fittings" Paragraph.

g. Waste Fittings: Comply with requirements in "Sink Waste Fittings" Paragraph.

h. Support: [Sink carrier, framing affixed][Sink carrier, floor affixed with steel uprights]<Insert carrier>.

i. Mounting Height: [Standard][Juvenile][Accessible in accordance with ICC A117.1].

E. Sacristy Sinks:

1. Sacristy Sinks - Stainless Steel, Wall Hung :

a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) [Just Manufacturing]
- 2) <Insert manufacturer's name>

b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of

the following:

- 1) **[Just Manufacturing]**
 - 2) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain sinks from single source from single manufacturer.
- d. Fixture:
- 1) Standard: ASME A112.19.3/CSA B45.4.
 - 2) Type: **[Single][Double]** bowl.
 - 3) Material: Bowl and hinged cover, 18 gauge, Type 304, 18-8 stainless steel.
 - 4) Nominal Size: Approximately **[20 by 23 inches (508 by 584 mm)][21 by 42 inches (533 by 1067 mm)]<Insert dimensions>**.
 - 5) Cover: Hinged with lock on **[left][right]** bowl.
- e. Faucet: **<Insert sink faucet designation from "Sink Faucets, Manually Operated" or "Sink Faucets, Automatically Operated" Paragraph>**.
- 1) Location: On **[left][right]** bowl.
- f. Supply Fittings: Comply with requirements in "Sink Supply Fittings" Paragraph.
- g. Waste Fittings:
- 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Bowl:
 - a) Orientation: **[Left][Right]**.
 - b) Drain: Cup with stopper and **NPS 1-1/2 (DN 40)** tailpiece.
 - 3) Opposite Bowl:
 - a) Drain: Grid with stopper and **NPS 1-1/2 (DN 40)** tailpiece.
 - 4) Trap Size: **NPS 1-1/2 (DN 40)**.
 - 5) Trap Material: Comply with requirements in "Waste Fittings" Article.
 - 6) Drain Piping: **NPS 1-1/2 (DN 40)** chrome-plated, tubular-brass direct waste without trap, separate waste piping, and wall flange.
2. Sacristy Sinks - Stainless Steel, Drop In, Two Bowl :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Just Manufacturing]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Just Manufacturing]**
 - 2) **<Insert manufacturer's name>**

- c. Source Limitations: Obtain sinks from single source from single manufacturer.
- d. Fixture:
 - 1) Standard: ASME A112.19.3/CSA B45.4.
 - 2) Type: Self-rimming.
 - 3) Material: Bowl and hinged cover, 18 gauge, Type 304, 18-8 stainless steel.
 - 4) Nominal Size: Approximately [17-1/2 by 37 inches (445 by 940 mm)][18 by 29 inches (460 by 740 mm)][22 by 28 inches (560 by 712 mm)][22 by 33 inches (560 by 0 mm)][22 by 42 inches (560 by 1070 mm)]<Insert dimensions>.
 - 5) Cover: Hinged with lock on [left][right] bowl.
- e. Faucet: <Insert sink faucet designation from "Sink Faucets, Manually Operated" or "Sink Faucets, Automatically Operated" Paragraph>.
 - 1) Location: On [left][right] bowl.
- f. Supply Fittings: Comply with requirements in "Sink Supply Fittings" Paragraph.
- g. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Bowl:
 - a) Orientation: [Left][Right].
 - b) Drain: Cup with stopper and **NPS 1-1/2 (DN 40)** tailpiece.
 - 3) Opposite Bowl:
 - a) Drain: Grid with stopper and **NPS 1-1/2 (DN 40)** tailpiece.
 - 4) Trap Size: **NPS 1-1/2 (DN 40)**.
 - 5) Trap Material: Comply with requirements in "Waste Fittings" Article.
 - 6) Drain Piping: **NPS 1-1/2 (DN 40)** chrome-plated, tubular-brass direct waste without trap, separate waste piping, and wall flange.

F. Shampoo Bowls:

- 1. Shampoo Bowls - Enameled Cast Iron :
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Belvedere, LLC]
 - 2) [Takara Belmont]
 - 3) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Belvedere, LLC]
 - 2) [Takara Belmont]
 - 3) <Insert manufacturer's name>

- c. Source Limitations: Obtain bowls from single source from single manufacturer.
 - d. Fixture:
 - 1) Standard: ASME A112.19.2/CSA B45.1.
 - 2) Bowl: Shaped for head rest.
 - 3) Nominal Size: **[19 by 19 by 10 inches (480 by 480 by 254 mm)]<Insert dimensions>**.
 - 4) Color: **[White]<Insert color>**.
 - e. Faucet: Manufacturer's standard with vacuum breaker complying with ASME A112.18.3 and with hose spray head.
 - f. Waste Fittings: Comply with requirements in "Sink Waste Fittings" Paragraph except as follows:
 - 1) Drain: Cup type with hair basket and **NPS 1-1/2 (DN 40)** tailpiece.
 - 2) Trap Size: **NPS 1-1/2 (DN 40)**.
 - g. Mounting Material: **[Bracket or devices for attaching to counter][Wall bracket]**.
2. Shampoo Bowls - Plastic :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Buy-Rite Beauty]**
 - 2) **[Collins]**
 - 3) **[Pibbs Industries]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Buy-Rite Beauty]**
 - 2) **[Collins]**
 - 3) **[Pibbs Industries]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain bowls from single source from single manufacturer.
 - d. Fixture:
 - 1) Standard: CSA B45.5/IAPMO Z124.
 - 2) Material: **[ABS][FRP][PMMA]<Insert material>**.
 - 3) Bowl: Shaped for head rest.
 - 4) Nominal Size: **[19 by 19 by 10 inches (483 by 483 by 250 mm)]<Insert dimensions>**.
 - 5) Color: **[White]<Insert color>**.
 - 6) Mounting Material: **[Bracket or devices for attaching to counter][Wall bracket]**.
 - e. Faucet: Manufacturer's standard with vacuum breaker complying with ASME A112.18.3 and with hose spray head.
 - f. Waste Fittings: Comply with requirements in "Sink Waste Fittings" Paragraph except as follows:

- 1) Drain: Cup type with hair basket and **NPS 1-1/2 (DN 40)** tailpiece.
- 2) Trap Size: **NPS 1-1/2 (DN 40)**.

3. Shampoo Bowls - Solid-Surface Material :

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) **[Willoughby Industries, Inc.]**
- 2) **<Insert manufacturer's name>**

- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) **[Willoughby Industries, Inc.]**
- 2) **<Insert manufacturer's name>**

- c. Source Limitations: Obtain bowls from single source from single manufacturer.

- d. Fixture:

- 1) Material: Molded, cast polymer.
- 2) Bowl: Shaped for head rest.
- 3) Nominal Size: **[19 by 19 by 9 inches (483 by 483 by 230 mm)][22 by 18 by 9 inches (560 by 469 by 230 mm)]<Insert dimensions>**.
- 4) Color: **[Gray granite][Sandstone][White granite]<Insert color>**.
- 5) Mounting Material: **[Bracket or devices for attaching to counter][Wall bracket]**.

- e. Faucet: Manufacturer's standard with vacuum breaker complying with ASME A112.18.3 and with hose spray head.

- f. Waste Fittings: Comply with requirements in "Sink Waste Fittings" Paragraph except as follows:

- 1) Drain: Cup type with hair basket and **NPS 1-1/2 (DN 40)** tailpiece.
- 2) Trap Size: **NPS 1-1/2 (DN 40)**.

G. Sink Faucets, Manually Operated:

1. Sink Faucets, Manually Operated : **[Single control, mixing][Single control, nonmixing][Two handle, mixing][Pre-rinse]<Insert type>**.

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) **[American Standard]**
- 2) **[Central Brass Company; a Pioneer Industries, Inc. brand]**
- 3) **[Chicago Faucets; Geberit Group]**
- 4) **[Elkay]**
- 5) **[Gerber Plumbing Fixtures LLC.]**
- 6) **[Just Manufacturing]**

- 7) [Kohler Co]
 - 8) [Krowne]
 - 9) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 10) [Speakman Company]
 - 11) [T&S Brass and Bronze Works, Inc.]
 - 12) [Wolverine Brass, Inc]
 - 13) [Zurn Industries, LLC]
 - 14) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [American Standard]
 - 2) [Central Brass Company; a Pioneer Industries, Inc. brand]
 - 3) [Chicago Faucets; Geberit Group]
 - 4) [Elkay]
 - 5) [Gerber Plumbing Fixtures LLC.]
 - 6) [Just Manufacturing]
 - 7) [Kohler Co]
 - 8) [Krowne]
 - 9) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 10) [Speakman Company]
 - 11) [T&S Brass and Bronze Works, Inc.]
 - 12) [Wolverine Brass, Inc]
 - 13) [Zurn Industries, LLC]
 - 14) <Insert manufacturer's name>
- c. Source Limitations: Obtain sink faucets from single source from single manufacturer.
- d. Standards:
- 1) ASME A112.18.1/CSA B125.1.
 - 2) NSF 61.
 - 3) NSF 372.
- e. Description: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
- f. Body Type: [Centerset][Widespread][Single hole]<Insert type>.
- g. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
- h. Finish: [Chrome plated][Polished chrome plate]<Insert finish>.
- i. Maximum Flow Rate: [1.0 to 1.28 gpm (3.8 to 4.8 L/min)][1.5 gpm (5.7 L/min)]<Insert value>.
- j. Mounting Type: [Deck, concealed][Deck, exposed][Back/wall, exposed].
- k. Valve Handle(s): [Lever][Cross, four arm][4-inch (102-mm) wrist blade][6-inch (150-mm) wrist blade][Not applicable]<Insert handles>.
- l. Spout Type: [Rigid][Rigid with wall brace][Swing][Rigid, gooseneck][Swivel, gooseneck]<Insert type>.
- m. Vacuum Breaker: [Required][Not required] for hose outlet.
- n. Spout Outlet: [Aerator][Laminar flow][Hose thread in accordance with ASME B1.20.7][Plain end][Spray]<Insert type>.
- o. Pre-Rinse Unit:
- 1) Style: [Flexible hose][Rigid][Combination rigid/flexible]<Insert type>.
 - 2) Riser: [18-inch (457-mm) rigid riser]<Insert type>.
 - 3) Hose: [44-inch (1117-mm) flexible stainless steel with heat-resistant

- handle]<Insert type>.
- 4) Spray valve: <Insert type>.
- 5) Wall bracket.
2. Sink Faucets, Manually Operated - Service Sink :
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- 1) [Acorn Engineering Company; a Division of Morris Group International]
- 2) [Central Brass Company; a Pioneer Industries, Inc. brand]
- 3) [Chicago Faucets; Geberit Group]
- 4) [Fiat Products]
- 5) [Just Manufacturing]
- 6) [Kohler Co]
- 7) [Krowne]
- 8) [Speakman Company]
- 9) [Stern-Williams Products, LLC.]
- 10) [T&S Brass and Bronze Works, Inc.]
- 11) [Zurn Industries, LLC]
- 12) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [Acorn Engineering Company; a Division of Morris Group International]
- 2) [Central Brass Company; a Pioneer Industries, Inc. brand]
- 3) [Chicago Faucets; Geberit Group]
- 4) [Fiat Products]
- 5) [Just Manufacturing]
- 6) [Kohler Co]
- 7) [Krowne]
- 8) [Speakman Company]
- 9) [Stern-Williams Products, LLC.]
- 10) [T&S Brass and Bronze Works, Inc.]
- 11) [Zurn Industries, LLC]
- 12) <Insert manufacturer's name>
- c. Source Limitations: Obtain sink faucets from single source from single manufacturer.
- d. Description: Wall/back mounted, brass body, with integral service stops, checks, spout with bucket/pail hook, 3/4-inch (20-mm) hose thread end, integral vacuum breaker, inlets 8 inches (203 mm) o.c., and two-handle mixing.
- e. Faucet:
- 1) Standards:
- a) ASME A112.18.1/CSA B125.1.
- b) NSF 61 and NSF 372.
- c) ICC A117.1.
- d) ASSE 1001 (VB).
- 2) Finish: [Rough chrome plated][Polished chrome plated]<Insert finish>.

- 3) Handles: **[Lever][6-inch (152-mm) wrist blade][4-inch (102-mm) wrist blade][four arms]<Insert type>**.
- 4) Cartridges: **[One-fourth turn compression][Ceramic]<Insert type>**.
- 5) Brace: **[Adjustable top brace][Adjustable bottom brace]<Insert type>**.
- f. Vacuum Breaker: **[Required][Not required]** for hose outlet.
- g. Spout Outlet: **[Aerator][Laminar flow][Hose thread in accordance with ASME B1.20.7][Plain end][Spray]<Insert type>**.

H. Sink Faucets, Automatically Operated:

- 1. Sink Faucets, Automatically Operated : **[Battery powered,][Hardwired,]** electronic sensor operated, **[mixing][nonmixing]**.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Chicago Faucets; Geberit Group]**
 - 2) **[Hydrotek International, Inc.]**
 - 3) **[Kohler Co]**
 - 4) **[Krowne]**
 - 5) **[Moen Incorporated]**
 - 6) **[Sloan Valve Company]**
 - 7) **[Speakman Company]**
 - 8) **[T&S Brass and Bronze Works, Inc.]**
 - 9) **[Zurn Industries, LLC]**
 - 10) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Chicago Faucets; Geberit Group]**
 - 2) **[Hydrotek International, Inc.]**
 - 3) **[Kohler Co]**
 - 4) **[Krowne]**
 - 5) **[Moen Incorporated]**
 - 6) **[Sloan Valve Company]**
 - 7) **[Speakman Company]**
 - 8) **[T&S Brass and Bronze Works, Inc.]**
 - 9) **[Zurn Industries, LLC]**
 - 10) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sink faucets from single source from single manufacturer.
 - d. Standards:
 - 1) **ASME A112.18.1/CSA B125.1.**
 - 2) **UL 1951.**
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - f. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
 - g. Body Type: **[Centerset][Single hole]<Insert type>**.

- h. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
- i. Finish: **[Chrome plated][Polished chrome1 plate]<Insert finish>**.
- j. Maximum Flow Rate: **[0.5 gpm (1.9 L/min)]<Insert value>**.
- k. Mounting Type: **[Deck][Back/wall]**.
- l. Spout Type: **[Rigid][Swing][Rigid, gooseneck][Swivel, gooseneck]<Insert type>**.
- m. Spout Outlet: **[Aerator][Laminar flow][Spray]<Insert type>**.
- n. Thermostatic Mixing Valve: **[Above deck,][Below deck,][Single temperature][adjustable temperature manual side handle, with hot/cold water indicators]**, with check valves.
- o. Control Module: **[Above deck,][Below deck,]** water-resistant module with internal flow setting switches.
- p. Drain: **[Not part of faucet]<Insert type>**.

I. Sink Supply Fittings:

- 1. NSF Standards: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.
- 2. Standard: ASME A112.18.1/CSA B125.1.
- 3. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless steel wall flange.
- 4. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- 5. Operation: **[Loose key][Wheel handle]<Insert type>**.
 - a. Risers Sizes: **[NPS 3/8 (DN 10)][NPS 1/2 (DN 15)]**.
 - b. Risers Material: **[Chrome-plated, rigid-copper pipe][Chrome-plated, soft-copper flexible tube][ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel flexible hose]**.

J. Sink Waste Fittings:

- 1. Standard: ASME A112.18.2/CSA B125.2.
- 2. Drain: Grid type with **NPS 1-1/2 (DN 40)** offset and straight tailpiece.
- 3. Trap:
 - a. Size: **NPS 1-1/2 (DN 40)**.
 - b. Material: Chrome-plated, **[two-piece, cast-brass trap and swivel elbow with 17-gauge brass tube to wall][two-piece, cast-brass trap and ground-joint swivel elbow with 17-gauge brass tube to wall][one-piece, cast-brass trap with swivel 17-gauge tubular brass wall bend]<Insert trap type>**; and chrome-plated brass or steel wall flange.

K. Grout:

- 1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- 2. Characteristics: Nonshrink; recommended for interior and exterior applications.
- 3. Design Mix: **5000 psi (34.5 MPa)**, 28-day compressive strength.
- 4. Packaging: Premixed and factory packaged.

2.5 COMMERCIAL URINALS

A. Urinals, Stall:

- 1. Urinals, Stall - Washout Type :

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Standard]**
 - 2) **[Kohler Co]**
 - 3) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Standard]**
 - 2) **[Kohler Co]**
 - 3) **<Insert manufacturer's name>**
- c. Fixture:
 - 1) Standards:
 - a) ASME A112.19.2/CSA B45.1.
 - b) ASME A112.19.5/CSA B45.15.
 - 2) Material: Vitreous china.
 - 3) Type: **[Straight or sloped]<Insert type>** front.
 - 4) Seam Covers: For **[21-inch (533-mm)][24-inch (610-mm)]** urinal centers.
 - 5) Strainer: Separate; removable.
 - 6) Water Consumption: **[0.5 gpf (1.9 Lpf)][1.0 gpf (3.8 Lpf)]**.
 - 7) Spud Size and Location: **NPS 3/4 (DN 20); [top][back]**.
 - 8) Outlet Size and Location: **NPS 2 (DN 50)**; bottom for separate trap.
 - 9) Color: **[White]<Insert color>**.
- d. Flushometer Valve: **<Insert urinal flushometer-valve designation from "Flushometer Valves" Article>**.

B. Urinals, Wall Hung:

1. Urinals, Wall Hung - Back Outlet, Blowout :

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Standard]**
 - 2) **[Kohler Co]**
 - 3) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Standard]**
 - 2) **[Kohler Co]**
 - 3) **<Insert manufacturer's name>**

- c. Fixture:
 - 1) Standards:
 - a) ASME A112.19.2/CSA B45.1.
 - b) ASME A112.19.5/CSA B45.15.
 - 2) Material: Vitreous china.
 - 3) Strainer or Trapway: **[Manufacturer's standard strainer][Open trapway]** with integral trap.
 - 4) Water Consumption: **[0.5 gpf (1.9 Lpf)][1.0 gpf (3.8 Lpf)]**.
 - 5) Spud Size and Location: **NPS 1-1/4 (DN 32); [back][top]**.
 - 6) Outlet Size and Location: **NPS 2 (DN 50); back**.
 - 7) Color: **[White]<Insert color>**.
 - d. Flushometer Valve: **<Insert urinal-flushometer-valve designation from "Flushometer Valves" Article>**.
 - e. Waste Fitting:
 - 1) Standard: ASME A112.18.2/CSA B125.2 for coupling.
 - 2) Size: **NPS 2 (DN 50)**.
 - f. Support: **[Urinal carrier, floor affixed with steel uprights]<Insert carrier>** with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.
 - g. Urinal Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
2. Urinals, Wall Hung - Back Outlet, Siphon Jet :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Standard]**
 - 2) **[Briggs Plumbing Products, Inc]**
 - 3) **[Duravit USA, Inc]**
 - 4) **[Gerber Plumbing Fixtures LLC.]**
 - 5) **[Kohler Co]**
 - 6) **[Mansfield Plumbing Products LLC]**
 - 7) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 8) **[Zurn Industries, LLC]**
 - 9) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Standard]**
 - 2) **[Briggs Plumbing Products, Inc]**
 - 3) **[Duravit USA, Inc]**
 - 4) **[Gerber Plumbing Fixtures LLC.]**
 - 5) **[Kohler Co]**
 - 6) **[Mansfield Plumbing Products LLC]**
 - 7) **[ProFlo; a Ferguson Enterprises, Inc. brand]**

- 8) [Zurn Industries, LLC]
 - 9) <Insert manufacturer's name>
 - c. Fixture:
 - 1) Standards:
 - a) ASME A112.19.2/CSA B45.1.
 - b) ASME A112.19.5/CSA B45.15.
 - 2) Material: Vitreous china.
 - 3) Type: Siphon jet[**with extended shields**].
 - 4) Strainer or Trapway: [Manufacturer's standard strainer]<Insert strainer> with integral trap.
 - 5) Water Consumption: [0.125 gpf (0.5 Lpf)][0.25 gpf (1.0 Lpf)][0.5 gpf (1.9 Lpf)][1.0 gpf (3.8 Lpf)].
 - 6) Spud Size and Location: NPS 3/4 (DN 20); [back][top].
 - 7) Outlet Size and Location: NPS 2 (DN 50); back.
 - 8) Color: [White]<Insert color>.
 - d. Flushometer Valve: <Insert urinal flushometer-valve designation from "Flushometer Valves" Article>.
 - e. Waste Fitting:
 - 1) Standard: ASME A112.18.2/CSA B125.2 for coupling.
 - 2) Size: NPS 2 (DN 50).
 - f. Support: [Urinal carrier, floor affixed with steel uprights]<Insert carrier> with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.
 - g. Urinal Mounting Height: [Standard][Juvenile][Accessible in accordance with ICC A117.1].
3. Urinals, Wall Hung - Back Outlet, Washout :
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Advanced Modern Technologies Corporation - AMTC]
 - 2) [American Standard]
 - 3) [Briggs Plumbing Products, Inc]
 - 4) [Gerber Plumbing Fixtures LLC.]
 - 5) [Kohler Co]
 - 6) [Mansfield Plumbing Products LLC]
 - 7) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 8) [TOTO USA, INC]
 - 9) [Zurn Industries, LLC]
 - 10) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Advanced Modern Technologies Corporation - AMTC]
 - 2) [American Standard]

- 3) [Briggs Plumbing Products, Inc]
 - 4) [Gerber Plumbing Fixtures LLC.]
 - 5) [Kohler Co]
 - 6) [Mansfield Plumbing Products LLC]
 - 7) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 8) [TOTO USA, INC]
 - 9) [Zurn Industries, LLC]
 - 10) <Insert manufacturer's name>
- c. Fixture:
- 1) Standards:
 - a) ASME A112.19.2/CSA B45.1.
 - b) ASME A112.19.5/CSA B45.15.
 - 2) Material: Vitreous china.
 - 3) Type: Washout with extended shields.
 - 4) Strainer or Trapway: [Manufacturer's standard strainer]<Insert strainer> with integral trap.
 - 5) Water Consumption: [0.125 gpf (0.5 Lpf)][0.25 gpf (1.0 Lpf)][0.5 gpf (1.9 Lpf)][1.0 gpf (3.8 Lpf)].
 - 6) Spud Size and Location: NPS 3/4 (DN 20), [back][top].
 - 7) Outlet Size and Location: NPS 2 (DN 50), back.
 - 8) Color: [White]<Insert color>.
- d. Flushometer Valve: <Insert urinal flushometer-valve designation from "Flushometer Valves" Article>.
- e. Waste Fitting:
- 1) Standard: ASME A112.18.2/CSA B125.2 for coupling.
 - 2) Size: NPS 2 (DN 50).
- f. Support: [Urinal carrier, floor affixed with steel uprights]<Insert carrier> with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.
- g. Urinal Mounting Height: [Standard][Juvenile][Accessible in accordance with ICC A117.1].
4. Urinals, Wall Hung - Bottom Outlet, Washout :
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [American Standard]
 - 2) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 3) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [American Standard]
 - 2) [ProFlo; a Ferguson Enterprises, Inc. brand]

- 3) <Insert manufacturer's name>
 - c. Fixture:
 - 1) Standards:
 - a) ASME A112.19.2/CSA B45.1.
 - b) ASME A112.19.5/CSA B45.15.
 - 2) Material: Vitreous china.
 - 3) Drain: Separate removable chrome-plated dome strainer with chrome-plated, **NPS 1-1/2 (DN 40)** tailpiece.
 - 4) Strainer or Trapway: Manufacturer's standard strainer and **NPS 1-1/2 (DN 40)** tailpiece.
 - 5) Inlet Spud Size and Location: **NPS 3/4 (DN 20)**; top.
 - 6) Outlet Size and Location: **NPS 1-1/2 (DN 40)**; bottom.
 - 7) Color: **[White]**<Insert color>.
 - 8) Water Consumption: **[0.125 gpf (0.5 Lpf)][0.25 gpf (1.0 Lpf)][0.5 gpf (1.9 Lpf)][1.0 gpf (3.8 Lpf)]**.
 - d. Flushometer Valve: <Insert urinal flushometer-valve designation from "Flushometer Valves" Article>.
 - e. Waste Fitting:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Trap:
 - a) Size: **NPS 1-1/2 (DN 50)**.
 - b) Material, Chrome Plated: **[Two-piece, cast-brass trap and swivel elbow with 0.032-inch- (0.83-mm-) thick brass tube to wall][two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch- (0.83-mm-) thick brass tube to wall][one-piece, cast-brass trap with swivel 0.029-inch- (73-mm-) thick tubular brass wall bend]**<Insert trap type>; and chrome-plated brass or steel wall flange.
 - c) Material, Stainless Steel: Two-piece trap and swivel elbow with **0.012-inch- (0.30-mm-) thick, stainless steel tube to wall; and stainless steel wall flange.**
 - f. Support: **[Urinal carrier, floor affixed with steel uprights]**<Insert carrier> with hanger and bearing plates.
 - g. Urinal Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
5. Urinals, Wall Hung - Back Outlet, Washdown :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Sloan Valve Company]**
 - 2) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) **[Sloan Valve Company]**
 - 2) **<Insert manufacturer's name>**
- c. Fixture:
- 1) Standards:
 - a) ASME A112.19.2/CSA B45.1.
 - b) ASME A112.19.5/CSA B45.15.
 - 2) Material: Vitreous china.
 - 3) Type: Washdown with extended shields.
 - 4) Strainer or Trapway: **[Manufacturer's standard strainer]<Insert strainer>** with integral trap.
 - 5) Water Consumption: **[0.125 gpf (0.5 Lpf)][0.25 gpf (1.0 Lpf)][0.5 gpf (1.9 Lpf)][1.0 gpf (3.8 Lpf)]**.
 - 6) Spud Size and Location: **NPS 3/4 (DN 20), [back][top]**.
 - 7) Outlet Size and Location: **NPS 2 (DN 50), back**.
 - 8) Color: **[White]<Insert color>**.
- d. Flushometer Valve: **<Insert urinal flushometer-valve designation from "Flushometer Valves" Article>**.
- e. Waste Fitting:
- 1) Standard: ASME A112.18.2/CSA B125.2 for coupling.
 - 2) Size: **NPS 2 (DN 50)**.
- f. Support: **[Urinal carrier, floor affixed with steel uprights]<Insert carrier>** with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.
- g. Urinal Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
- C. Urinals, Waterless:
1. Urinals, Waterless - Vitreous China, Wall Hung, Back Outlet :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Duravit USA, Inc]**
 - 2) **[Falcon Waterfree Technologies]**
 - 3) **[Kohler Co]**
 - 4) **[Sloan Valve Company]**
 - 5) **[Waterless Co]**
 - 6) **[Zero Flush]**
 - 7) **[Zurn Industries, LLC]**
 - 8) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Duravit USA, Inc]**

- 2) **[Falcon Waterfree Technologies]**
- 3) **[Kohler Co]**
- 4) **[Sloan Valve Company]**
- 5) **[Waterless Co]**
- 6) **[Zero Flush]**
- 7) **[Zurn Industries, LLC]**
- 8) **<Insert manufacturer's name>**

c. Fixture:

- 1) Standard: ASME A112.19.2/CSA B45.1, except without water supply.
- 2) Designed for liquid-trap-seal operation.
- 3) Trap-Seal Method: Proprietary cartridge with liquid seal.
- 4) Outlet Size and Location: **[NPS 2 (DN 50)]<Insert pipe size>** flange; back.
- 5) Trap-Sealing Liquid: Proprietary.
- 6) Color: **[White]<Insert color>**.

d. Waste Fitting:

- 1) Standard: ASME A112.18.2/CSA B125.2 for transition coupling, trap, and waste pipe.
- 2) Size: **[NPS 2 (DN 50)]<Insert pipe size>**.

e. Support: **[Urinal carrier, floor affixed with steel uprights]<Insert carrier>** with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.

f. Urinal Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.

2. Urinals, Waterless - Plastic, Wall Hung, Back Outlet :

a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) **[Waterless Co]**
- 2) **<Insert manufacturer's name>**

b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) **[Waterless Co]**
- 2) **<Insert manufacturer's name>**

c. Fixture:

- 1) Standard: CSA B45.5/IAPMO Z124, except without water supply.
- 2) Designed for liquid-trap-seal operation.
- 3) Material: **[FRP]<Insert material>**.
- 4) Trap-Seal Method: Proprietary cartridge or trap system.
- 5) Outlet Size and Location: **NPS 2 (DN 50)**; back. Include transition coupling.
- 6) Trap-Sealing Liquid: Proprietary.
- 7) Color: **[White]<Insert color>**.

d. Waste Fitting:

- 1) Standard: ASME A112.18.2/CSA B125.2 for transition coupling, trap, and waste pipe.
- 2) Size: **[NPS 2 (DN 50)]<Insert pipe size>**.
- e. Support: **[Metal plate in wall][Wood blocking in wall][Urinal carrier, floor affixed with steel uprights]<Insert carrier>[with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture]**.
- f. Urinal Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.

2.6 COMMERCIAL WATER CLOSETS

A. Water Closets, Floor Mounted:

1. Water Closets, Floor Mounted - Bottom Outlet, Top Spud :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Advanced Modern Technologies Corporation - AMTC]**
 - 2) **[American Standard]**
 - 3) **[Briggs Plumbing Products, Inc]**
 - 4) **[Gerber Plumbing Fixtures LLC.]**
 - 5) **[Kohler Co]**
 - 6) **[Mansfield Plumbing Products LLC]**
 - 7) **[Sloan Valve Company]**
 - 8) **[TOTO USA, INC]**
 - 9) **[Zurn Industries, LLC]**
 - 10) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Advanced Modern Technologies Corporation - AMTC]**
 - 2) **[American Standard]**
 - 3) **[Briggs Plumbing Products, Inc]**
 - 4) **[Gerber Plumbing Fixtures LLC.]**
 - 5) **[Kohler Co]**
 - 6) **[Mansfield Plumbing Products LLC]**
 - 7) **[Sloan Valve Company]**
 - 8) **[TOTO USA, INC]**
 - 9) **[Zurn Industries, LLC]**
 - 10) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain water closets from single source from single manufacturer.
 - d. Standard: ASME A112.19.2/CSA B45.1.
 - e. Bowl:
 - 1) Material: Vitreous china.
 - 2) Type: Siphon jet.
 - 3) Style: Flushometer valve.

- 4) Height: **[Standard][Accessible in accordance with ICC A117.1]**.
 - 5) Rim Contour: Elongated.
 - 6) Water Consumption: **[1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)][Dual flush 1.1 gal. (4.2 L)/1.28 gal. (4.8 L)][Dual flush 1.1 gal. (4.2 L)/1.6 gal. (6 L)]** per flush.
 - 7) Spud Size and Location: **NPS 1-1/2 (DN 40)**; top.
 - 8) Color: **[White]<Insert color>**.
- f. Flushometer Valve: **<Insert flushometer-valve designation>**.
 - g. Toilet Seat: **<Insert toilet-seat designation>**.
2. Water Closets, Floor Mounted - Bottom Outlet, Back Spud :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Standard]**
 - 2) **[Kohler Co]**
 - 3) **[Mansfield Plumbing Products LLC]**
 - 4) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 5) **[Sloan Valve Company]**
 - 6) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Standard]**
 - 2) **[Kohler Co]**
 - 3) **[Mansfield Plumbing Products LLC]**
 - 4) **[ProFlo; a Ferguson Enterprises, Inc. brand]**
 - 5) **[Sloan Valve Company]**
 - 6) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain water closets from single source from single manufacturer.
 - d. Standard: ASME A112.19.2/CSA B45.1
 - e. Bowl:
 - 1) Material: Vitreous china.
 - 2) Type: Siphon jet.
 - 3) Style: Flushometer valve.
 - 4) Height: **[Standard][Accessible in accordance with ICC A117.1]**.
 - 5) Rim Contour: Elongated.
 - 6) Water Consumption: **[1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)][Dual flush 1.1gal. (4.2 L)/1.28 gal. (4.8 L)][Dual flush 1.1 gal. (4.2 L)/1.6 gal. (6 L)]** per flush.
 - 7) Spud Size and Location: **NPS 1-1/2 (DN 40)**; back.
 - 8) Color: **[White]<Insert color>**.
 - f. Flushometer Valve: **<Insert flushometer-valve designation>**.
 - g. Toilet Seat: **<Insert toilet-seat designation>**.
 3. Water Closets, Floor Mounted - Bottom Outlet, Close-Coupled Flushometer Tank :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) [American Standard]
 - 2) [Briggs Plumbing Products, Inc]
 - 3) [Kohler Co]
 - 4) [Sloan Valve Company]
 - 5) [Zurn Industries, LLC]
 - 6) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [American Standard]
 - 2) [Briggs Plumbing Products, Inc]
 - 3) [Kohler Co]
 - 4) [Sloan Valve Company]
 - 5) [Zurn Industries, LLC]
 - 6) <Insert manufacturer's name>
- c. Source Limitations: Obtain water closets from single source from single manufacturer.
- d. Standard: ASME A112.19.2/CSA B45.1.
- e. Bowl:
- 1) Material: Vitreous china.
 - 2) Type: Siphon jet.
 - 3) Style: Flushometer tank, [gravity][pressure assisted].
 - 4) Height: [Standard][Accessible in accordance with ICC A117.1].
 - 5) Rim Contour: Elongated.
 - 6) Water Consumption: [1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)][Dual flush 1.1 gal. (4.2 L)/1.6 gal. (6 L)] per flush.
 - 7) Color: [White]<Insert color>.
- f. Toilet Seat: <Insert toilet-seat designation>.
4. Water Closets, Floor Mounted - Bottom Outlet, Juvenile :
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- 1) [American Standard]
 - 2) [Kohler Co]
 - 3) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 4) [Sloan Valve Company]
 - 5) [Zurn Industries, LLC]
 - 6) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [American Standard]

- 2) [Kohler Co]
 - 3) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 4) [Sloan Valve Company]
 - 5) [Zurn Industries, LLC]
 - 6) <Insert manufacturer's name>
 - c. Source Limitations: Obtain water closets from single source from single manufacturer.
 - d. Standard: ASME A112.19.2/CSA B45.1.
 - e. Bowl:
 - 1) Material: Vitreous china.
 - 2) Type: Siphon jet.
 - 3) Style: Flushometer valve.
 - 4) Height: [10 inches (254 mm)][14 inches (356 mm)]<Insert height>.
 - 5) Rim Contour: Elongated.
 - 6) Water Consumption: [1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)] per flush.
 - 7) Spud Size and Location: NPS 1-1/2 (DN 40); top.
 - 8) Color: [White]<Insert color>.
 - f. Flushometer Valve: <Insert flushometer-valve designation>.
 - g. Toilet Seat: <Insert toilet-seat designation>.
5. Water Closets, Floor Mounted - Back Outlet, Top Spud :
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [American Standard]
 - 2) [Kohler Co]
 - 3) [Mansfield Plumbing Products LLC]
 - 4) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 5) [Sloan Valve Company]
 - 6) [Zurn Industries, LLC]
 - 7) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [American Standard]
 - 2) [Kohler Co]
 - 3) [Mansfield Plumbing Products LLC]
 - 4) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 5) [Sloan Valve Company]
 - 6) [Zurn Industries, LLC]
 - 7) <Insert manufacturer's name>
 - c. Source Limitations: Obtain water closets from single source from single manufacturer.
 - d. Standard: ASME A112.19.2/CSA B45.1
 - e. Bowl:
 - 1) Material: Vitreous china.
 - 2) Type: Siphon jet.
 - 3) Style: Flushometer valve.

- 4) Height: **[Standard][Accessible in accordance with ICC A117.1]**.
 - 5) Rim Contour: Elongated.
 - 6) Water Consumption: **[1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)][Dual flush 1.1 gal. (4.2 L)/1.28 gal. (4.8 L)][Dual flush 1.1 gal. (4.2 L)/1.6 gal. (6 L)]** per flush.
 - 7) Spud Size and Location: **NPS 1-1/2 (DN 40)**; top.
 - 8) Color: **[White]<Insert color>**.
- f. Flushometer Valve: **<Insert flushometer-valve designation>**.
 - g. Toilet Seat: **<Insert toilet-seat designation>**.
 - h. Support: **[Water-closet carrier, floor affixed]<Insert carrier>**.
6. Water Closets, Floor Mounted - Back Outlet, Back Spud :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Kohler Co]**
 - 2) **[Sloan Valve Company]**
 - 3) **[Zurn Industries, LLC]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Kohler Co]**
 - 2) **[Sloan Valve Company]**
 - 3) **[Zurn Industries, LLC]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain water closets from single source from single manufacturer.
 - d. Standard: ASME A112.19.2/CSA B45.1.
 - e. Bowl:
 - 1) Material: Vitreous china.
 - 2) Type: Siphon jet.
 - 3) Style: Flushometer valve.
 - 4) Height: **[Standard][Accessible in accordance with ICC A117.1]**.
 - 5) Rim Contour: Elongated.
 - 6) Water Consumption: **[1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)][Dual flush 1.1 gal. (4.2 L)/1.28 gal. (4.8 L)][Dual flush 1.1 gal. (4.2 L)/1.6 gal. (6 L)]** per flush.
 - 7) Spud Size and Location: **NPS 1-1/2 (DN 40)**; back.
 - 8) Color: **[White]<Insert color>**.
 - f. Flushometer Valve: **<Insert flushometer-valve designation>**.
 - g. Toilet Seat: **<Insert toilet-seat designation>**.
 - h. Support: **[Water-closet carrier, floor affixed]<Insert carrier>**.
7. Water Closets, Floor Mounted - Back Outlet, Close-Coupled Flushometer Tank :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- 1) [American Standard]
- 2) [Kohler Co]
- 3) [Mansfield Plumbing Products LLC]
- 4) <Insert manufacturer's name>

- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) [American Standard]
- 2) [Kohler Co]
- 3) [Mansfield Plumbing Products LLC]
- 4) <Insert manufacturer's name>

- c. Source Limitations: Obtain water closets from single source from single manufacturer.
- d. Standard: ASME A112.19.2/CSA B45.1.
- e. Bowl:

- 1) Material: Vitreous china.
- 2) Type: Siphon jet.
- 3) Style: Flushometer tank, [gravity][pressure assisted].
- 4) Height: [Standard][Accessible in accordance with ICC A117.1].
- 5) Rim Contour: Elongated.
- 6) Water Consumption: [1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)] per flush.
- 7) Color: [White]<Insert color>.

- f. Toilet Seat: <Insert toilet-seat designation>.
- g. Support: [Water-closet carrier, floor affixed]<Insert carrier>.

B. Water Closets, Wall Mounted:

1. Water Closets, Wall Mounted - Top Spud :

- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) [Advanced Modern Technologies Corporation - AMTC]
- 2) [American Standard]
- 3) [Briggs Plumbing Products, Inc]
- 4) [Gerber Plumbing Fixtures LLC.]
- 5) [Kohler Co]
- 6) [Mansfield Plumbing Products LLC]
- 7) [ProFlo; a Ferguson Enterprises, Inc. brand]
- 8) [Sloan Valve Company]
- 9) [TOTO USA, INC]
- 10) [Zurn Industries, LLC]
- 11) <Insert manufacturer's name>

- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) [Advanced Modern Technologies Corporation - AMTC]
 - 2) [American Standard]
 - 3) [Briggs Plumbing Products, Inc]
 - 4) [Gerber Plumbing Fixtures LLC.]
 - 5) [Kohler Co]
 - 6) [Mansfield Plumbing Products LLC]
 - 7) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 8) [Sloan Valve Company]
 - 9) [TOTO USA, INC]
 - 10) [Zurn Industries, LLC]
 - 11) <Insert manufacturer's name>
- c. Source Limitations: Obtain water closets from single source from single manufacturer.
- d. Standard: ASME A112.19.2/CSA B45.1.
- e. Bowl:
- 1) Material: Vitreous china.
 - 2) Type: Siphon jet.
 - 3) Style: Flushometer valve.
 - 4) Mounting Height: [Standard][Juvenile][Accessible in accordance with ICC A117.1].
 - 5) Rim Contour: Elongated.
 - 6) Water Consumption: [1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)][Dual flush 1.1 gal. (4.2 L)/1.28 gal. (4.8 L)][Dual flush 1.1 gal. (4.2 L)/1.6 gal. (6 L)] per flush.
 - 7) Spud Size and Location: NPS 1-1/2 (DN 40); top.
 - 8) Color: [White]<Insert color>.
- f. Flushometer Valve: <Insert flushometer-valve designation>.
- g. Toilet Seat: <Insert toilet-seat designation>.
- h. Support: [Water-closet carrier, floor affixed]<Insert carrier>.
2. Water Closets, Wall Mounted - Back Spud :
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [American Standard]
 - 2) [Kohler Co]
 - 3) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 4) [Sloan Valve Company]
 - 5) [TOTO USA, INC]
 - 6) [Zurn Industries, LLC]
 - 7) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [American Standard]
 - 2) [Kohler Co]
 - 3) [ProFlo; a Ferguson Enterprises, Inc. brand]
 - 4) [Sloan Valve Company]
 - 5) [TOTO USA, INC]

- 6) **[Zurn Industries, LLC]**
 - 7) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain water closets from single source from single manufacturer.
- d. Standard: ASME A112.19.2/CSA B45.1.
- e. Bowl:
- 1) Material: Vitreous china.
 - 2) Type: Siphon jet.
 - 3) Style: Flushometer valve.
 - 4) Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1].**
 - 5) Rim Contour: Elongated.
 - 6) Water Consumption: **[1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)][Dual flush 1.1 gal. (4.2 L)/1.28 gal. (4.8 L)][Dual flush 1.1 gal. (4.2 L)/1.6 gal. (6 L)]** per flush.
 - 7) Spud Size and Location: **NPS 1-1/2 (DN 40); back.**
 - 8) Color: **[White]<Insert color>.**
- f. Flushometer Valve: **<Insert flushometer-valve designation>.**
- g. Toilet Seat: **<Insert toilet-seat designation>.**
- h. Support: **[Water-closet carrier, floor affixed]<Insert carrier>.**
3. Water Closets, Wall Mounted - Back Outlet, Close-Coupled Flushometer Tank :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
- 1) **[American Standard]**
 - 2) **[Mansfield Plumbing Products LLC]**
 - 3) **[TOTO USA, INC]**
 - 4) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[American Standard]**
 - 2) **[Mansfield Plumbing Products LLC]**
 - 3) **[TOTO USA, INC]**
 - 4) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain water closets from single source from single manufacturer.
- d. Standard: ASME A112.19.2/CSA B45.1.
- e. Bowl:
- 1) Material: Vitreous china.
 - 2) Type: Siphon jet.
 - 3) Style: Flushometer tank, **[gravity][pressure assisted].**
 - 4) Height: **[Standard][Accessible in accordance with ICC A117.1].**
 - 5) Rim Contour: Elongated.
 - 6) Water Consumption: **[1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)]** per flush.
 - 7) Color: **[White]<Insert color>.**
- f. Toilet Seat: **<Insert toilet-seat designation>.**

- g. Support: **[Water-closet carrier, floor affixed]<Insert carrier>**.

2.7 COMMERCIAL WASH FOUNTAINS

A. Wash Fountains, Circular Receptor:

1. Wash Fountains, Circular Receptor - Solid Surface :

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) **[Aqua Design Manufacturing]**
- 2) **[Bradley Corporation]**
- 3) **[Willoughby Industries, Inc.]**
- 4) **<Insert manufacturer's name>**

- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) **[Aqua Design Manufacturing]**
- 2) **[Bradley Corporation]**
- 3) **[Willoughby Industries, Inc.]**
- 4) **<Insert manufacturer's name>**

- c. Source Limitations: Obtain wash fountains from single source from single manufacturer.

- d. Standards:

- 1) IAPMO IGC 156.
- 2) CSA B45.5/IAPMO Z124.
- 3) ASME A112.18.1/CSA B125.1.

- e. Receptor:

- 1) Nominal Diameter: **[36 inches (914 mm)][or][39 inches (990 mm)][54 inches (1370 mm)]**.
- 2) Height to Rim: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
- 3) Color or Finish: **[Not applicable]<Insert if required>**.
- 4) Drain: Grid with **[NPS 2 (DN 50)]<Insert pipe size>** tailpiece.

- f. Spray Head:

- 1) Material: Stainless steel.
- 2) Number of User Stations: **<Insert number>**.
- 3) Control: **[Collective,][Individual,][foot-control][pneumatic push-button][infrared sensor][low-voltage, mechanical metering]** actuation with **[pressure-balancing][thermostatic]** mixing valve, and having check stops.

- g. Soap Dispensers: **[Not required][Bracket only][Foam][Powdered][Liquid]<Insert type>**, for each user station.

- h. Pedestal: **[Manufacturer's standard][Painted or coated steel][Stainless steel]** with access panel.

- i. Supply Fittings:
 - 1) Piping: **[NPS 3/4 (DN 20)][NPS 1 (DN 25)]** copper tubing.
 - 2) Valves: Shutoff valve on each supply.
 - 3) Supply Piping: From **[bottom][top]**.
 - j. Waste Fittings:
 - 1) Trap and Drain Piping: **[NPS 2 (DN 50)]<Insert size>**.
 - 2) Vent Piping: **[Not required][NPS 1-1/2 (DN 40) to ceiling]**.
 - k. Shroud: **[Not required][Stainless steel of size to cover supply and vent piping]**.
 - l. Mounting: Manufacturer's standard floor bracket.
2. Wash Fountains, Circular Receptor - Stainless Steel :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Aqua Design Manufacturing]**
 - 3) **[Bradley Corporation]**
 - 4) **[Willoughby Industries, Inc.]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Aqua Design Manufacturing]**
 - 3) **[Bradley Corporation]**
 - 4) **[Willoughby Industries, Inc.]**
 - 5) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain wash fountains from single source from single manufacturer.
 - d. Standards:
 - 1) IAPMO IGC 156.
 - 2) ASME A112.18.1/CSA B125.1
 - 3) ASME A112.19.3/CSA B45.4.
 - e. Receptor:
 - 1) Nominal Diameter: **[36 inches (914 mm)][or][39 inches (990 mm)][42 inches (1067 mm)][54 inches (1372 mm)]**.
 - 2) Height to Rim: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
 - 3) Color or Finish: **[Not applicable]<Insert if required>**.
 - 4) Drain: Grid with **[NPS 2 (DN 50)]<Insert pipe size>** tailpiece.
 - f. Spray Head:
 - 1) Material: Stainless steel.
 - 2) Number of User Stations: **<Insert number>**.

- 3) Control: **[Collective,][Individual,][foot-control][pneumatic push-button][infrared sensor][low-voltage, mechanical metering]** actuation with **[pressure-balancing][thermostatic]** mixing valve, and having check stops.
- g. Soap Dispensers: **[Not required][Bracket only][Foam][Powdered][Liquid]<Insert type>** for each user station.
- h. Pedestal: Stainless steel with access panel.
- i. Supply Fittings:
- 1) Piping: **[NPS 3/4 (DN 20)][NPS 1 (DN 25)]** copper tubing.
 - 2) Valves: Shutoff valve on each supply.
 - 3) Supply Piping: From **[bottom][top]**.
- j. Waste Fittings:
- 1) Trap and Drain Piping: **[NPS 2 (DN 50)]<Insert size>**.
 - 2) Vent Piping: **[Not required][NPS 1-1/2 (DN 40) to ceiling]**.
- k. Shroud: **[Not required][Stainless steel of size to cover supply and vent piping]**.
- l. Mounting: Manufacturer's standard floor bracket.
- B. Wash Fountains, Semicircular Receptor:
1. Wash Fountains, Semicircular Receptor - Solid Surface, Floor or Wall Mounted :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Aqua Design Manufacturing]**
 - 3) **[Bradley Corporation]**
 - 4) **[Sloan Valve Company]**
 - 5) **[Willoughby Industries, Inc.]**
 - 6) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Aqua Design Manufacturing]**
 - 3) **[Bradley Corporation]**
 - 4) **[Sloan Valve Company]**
 - 5) **[Willoughby Industries, Inc.]**
 - 6) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain wash fountains from single source from single manufacturer.
 - d. Standards:
 - 1) IAPMO IGC 156.
 - 2) ASME A112.18.1/CSA B125.1.
 - 3) CSA B45.5/IAPMO Z124.

- e. Receptor:
 - 1) Nominal Diameter: [36 inches (914 mm)][or][39 inches (990 mm)][46 inches (1168 mm)][54 inches (1372 mm)].
 - 2) Height to Rim: [Standard][Juvenile][Accessible in accordance with ICC A117.1].
 - 3) Color or Finish: [Not applicable]<Insert if required>.
 - 4) Drain: Grid with [NPS 1-1/2 (DN 40)][NPS 2 (DN 50)] tailpiece.
 - f. Spray Head:
 - 1) Material: Stainless steel or integral part of receptor back.
 - 2) Number of User Stations: <Insert number>.
 - 3) Control: [Collective,][Individual,][foot-control][pneumatic push-button][infrared sensor][low-voltage, mechanical metering]<Insert type> actuation with [pressure-balancing][thermostatic] mixing valve, and having check stops.
 - g. Soap Dispensers: [Not required][Bracket only][Foam][Powdered][Liquid]<Insert type>, for each user station.
 - h. Supply Fittings:
 - 1) Piping: [NPS 1/2 (DN 15)][NPS 3/4 (DN 20)] copper tubing.
 - 2) Valves: Shutoff valve on each supply.
 - 3) Supply Piping: From [bottom][top][wall].
 - i. Waste Fittings:
 - 1) Trap and Drain Piping: [NPS 1-1/2 (DN 40)][NPS 2 (DN 50)].
 - 2) Vent Piping: [Not required][NPS 1-1/2 (DN 40) to ceiling].
 - j. Shroud: [Not required][Stainless steel of size to cover supply and vent piping].
 - k. Wall Mounting: [Manufacturer's wall-mounting bracket][and/or][wash fountain carrier]<Insert type>.
 - l. Floor Mounting: Manufacturer's floor bracket and wall bracket attached to [reinforcement in][concrete or block] wall.
2. Wash Fountains, Semicircular Receptor - Stainless Steel, Floor or Wall Mounted :
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Acorn Engineering Company; a Division of Morris Group International]
 - 2) [Aqua Design Manufacturing]
 - 3) [Bradley Corporation]
 - 4) [Willoughby Industries, Inc.]
 - 5) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Acorn Engineering Company; a Division of Morris Group International]
 - 2) [Aqua Design Manufacturing]
 - 3) [Bradley Corporation]
 - 4) [Willoughby Industries, Inc.]



- 5) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain wash fountains from single source from single manufacturer.
 - d. Standards:
 - 1) IAPMO IGC 156.
 - 2) ASME A112.18.1/CSA B125.1.
 - 3) ASME A112.19.3/CSA B45.4.
 - e. Receptor:
 - 1) Nominal Diameter: **[36 inches (914 mm)][or][39 inches (990 mm)][42 inches (1067 mm)][54 inches (1372 mm)]**.
 - 2) Height to Rim: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
 - 3) Color or Finish: **[Not applicable]<Insert if required>**.
 - 4) Drain: Grid with **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]** tailpiece.
 - f. Spray Head:
 - 1) Material: Stainless steel or integral part of receptor back.
 - 2) Number of User Stations: **<Insert number>**.
 - 3) Control: **[Collective,][Individual,][foot-control][pneumatic push-button][infrared sensor][low-voltage, mechanical metering]<Insert type>** actuation with **[pressure-balancing][thermostatic]** mixing valve, and having check stops.
 - g. Soap Dispensers: **[Not required][Bracket only][Foam][Powdered][Liquid]<Insert type>**, for each user station.
 - h. Supply Fittings:
 - 1) Piping: **[NPS 1/2 (DN 15)][NPS 3/4 (DN 20)]** copper tubing.
 - 2) Valves: Shutoff valve on each supply.
 - 3) Supply Piping: From **[bottom][top][wall]**.
 - i. Waste Fittings:
 - 1) Trap and Drain Piping: **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]**.
 - 2) Vent Piping: **[Not required][NPS 1-1/2 (DN 40) to ceiling]**.
 - j. Shroud: **[Not required][Stainless steel of size to cover supply and vent piping]**.
 - k. Wall Mounting: **[Manufacturer's wall-mounting bracket][and/or][wash fountain carrier]<Insert type>**.
 - l. Floor Mounting: Manufacturer's floor bracket and wall bracket attached to **[reinforcement in][concrete or block]** wall.
- C. Wash Fountains, Corner Receptor:
1. Wash Fountains, Corner Receptor - Precast Terrazzo :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Bradley Corporation]**

- 3) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Bradley Corporation]**
 - 3) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain wash fountains from single source from single manufacturer.
- d. Standards:
 - 1) IAPMO IGC 156.
 - 2) ASME A112.18.1/CSA B125.1.
 - 3) CSA B45.8/IAPMO Z403.
- e. Receptor:
 - 1) Nominal Side Width: **[27 inches (685 mm)][37 inches (940 mm)]**.
 - 2) Height to Rim: **[Standard][Juvenile]**.
 - 3) Color or Finish: **[Not applicable]<Insert if required>**.
 - 4) Drain: Grid with **NPS 1-1/2 (DN 40)** tailpiece.
- f. Spray Head:
 - 1) Material: Stainless steel or integral part of receptor back.
 - 2) Number of User Stations: **<Insert number>**.
 - 3) Control: **[Foot-control][Pneumatic push-button][Infrared sensor][Low-voltage, mechanical metering]<Insert type>** actuation with **[pressure-balancing][thermostatic]** mixing valve, and having check stops.
- g. Soap Dispensers: **[Not required][Bracket only][Foam][Powdered][Liquid]<Insert type>**, for each user station.
- h. Supply Fittings:
 - 1) Piping: **[NPS 1/2 (DN 15)][NPS 3/4 (DN 20)]** copper tubing.
 - 2) Valves: Shutoff valve on each supply.
 - 3) Supply Piping: From wall.
- i. Waste Fittings:
 - 1) Trap and Drain Piping: **NPS 1-1/2 (DN 40)**.
- j. Mounting: Manufacturer's standard floor and wall bracket.
2. Wash Fountains, Corner Receptor - Solid Surface, Floor or Wall Mounted :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Bradley Corporation]**
 - 3) **[Willoughby Industries, Inc.]**



- 4) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Acorn Engineering Company; a Division of Morris Group International]
 - 2) [Bradley Corporation]
 - 3) [Willoughby Industries, Inc.]
 - 4) <Insert manufacturer's name>
- c. Source Limitations: Obtain wash fountains from single source from single manufacturer.
- d. Standards:
 - 1) IAPMO IGC 156.
 - 2) ASME A112.18.1/CSA B125.1.
 - 3) CSA B45.5/IAPMO Z124.
- e. Receptor:
 - 1) Nominal Side Width: [27 inches (685 mm)][37 inches (940 mm)].
 - 2) Height to Rim: [Standard][Juvenile][Accessible in accordance with ICC A117.1].
 - 3) Color or Finish: [Not applicable]<Insert if required>.
 - 4) Drain: Grid with NPS 1-1/2 (DN 40) tailpiece.
- f. Spray Head:
 - 1) Material: Stainless steel or integral part of receptor back.
 - 2) Number of User Stations: <Insert number>.
 - 3) Control: [Collective,][Individual,][foot-control][pneumatic push-button][infrared sensor][low-voltage, mechanical metering]<Insert type> actuation with [pressure-balancing][thermostatic] mixing valve, and having check stops.
- g. Soap Dispensers: [Not required][Bracket only][Foam][Powdered][Liquid]<Insert type>, for each user station.
- h. Supply Fittings:
 - 1) Piping: [NPS 1/2 (DN 15)][NPS 3/4 (DN 20)] copper tubing.
 - 2) Valves: Shutoff valve on each supply.
 - 3) Supply Piping: From wall.
- i. Waste Fittings:
 - 1) Trap and Drain Piping: NPS 1-1/2 (DN 40).
- j. Wall Mounting: [Manufacturer's wall-mounting bracket][and/or][wash fountain carrier]<Insert type>.
- k. Floor Mounting: Manufacturer's floor bracket and wall bracket attached to [reinforcement in][concrete or block] wall.
3. Wash Fountains, Corner Receptor - Stainless Steel, Floor or Wall Mounted :
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the

following]:

- 1) [Acorn Engineering Company; a Division of Morris Group International]
 - 2) [Bradley Corporation]
 - 3) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [Acorn Engineering Company; a Division of Morris Group International]
 - 2) [Bradley Corporation]
 - 3) <Insert manufacturer's name>
- c. Source Limitations: Obtain wash fountains from single source from single manufacturer.
- d. Standards:
- 1) IAPMO IGC 156.
 - 2) ASME A112.18.1/CSA B125.1
 - 3) ASME A112.19.3/CSA 45.4.
- e. Receptor:
- 1) Nominal Side Width: [37 inches (940 mm)][38 inches (965 mm)][44 inches (1118 mm)].
 - 2) Height to Rim: [Standard][Juvenile][Accessible in accordance with ICC A117.1].
 - 3) Color or Finish: [Not applicable]<Insert if required>.
 - 4) Drain: Grid with NPS 1-1/2 (DN 40) tailpiece.
- f. Spray Head:
- 1) Material: Stainless steel or integral part of receptor back.
 - 2) Number of User Stations: <Insert number>.
 - 3) Control: [Collective,][Individual,][foot-control][pneumatic push-button][infrared sensor][low-voltage, mechanical metering]<Insert type> actuation with [pressure-balancing][thermostatic] mixing valve, and having check stops.
- g. Soap Dispensers: [Not required][Bracket only][Foam][Powdered][Liquid]<Insert type>, for each user station.
- h. Supply Fittings:
- 1) Piping: [NPS 1/2 (DN 15)][NPS 3/4 (DN 20)] copper tubing.
 - 2) Valves: Shutoff valve on each supply.
 - 3) Supply Piping: From wall.
- i. Waste Fittings:
- 1) Trap and Drain Piping: NPS 1-1/2 (DN 40).
- j. Wall Mounting: [Manufacturer's wall-mounting bracket][and/or][wash fountain carrier]<Insert type>.
- k. Floor Mounting: Manufacturer's floor bracket and wall bracket attached to [reinforcement in][concrete or block] wall.

D. Wash Fountains, Linear Receptor:

1. Wash Fountains, Linear Receptor - Solid Surface :
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Acorn Engineering Company; a Division of Morris Group International]
 - 2) [Aqua Design Manufacturing]
 - 3) [Bradley Corporation]
 - 4) [Sloan Valve Company]
 - 5) [Willoughby Industries, Inc.]
 - 6) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Acorn Engineering Company; a Division of Morris Group International]
 - 2) [Aqua Design Manufacturing]
 - 3) [Bradley Corporation]
 - 4) [Sloan Valve Company]
 - 5) [Willoughby Industries, Inc.]
 - 6) <Insert manufacturer's name>
 - c. Source Limitations: Obtain wash fountains from single source from single manufacturer.
 - d. Standards:
 - 1) ASME A112.18.1/CSA B125.1.
 - 2) CSA B45.5/IAPMO Z124.
 - 3) NSF 61.
 - 4) NSF 372.
 - 5) Uniform Plumbing Code, International Plumbing Code, and UL GREENGUARD certified.
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - f. Bowl(s) and Counter:
 - 1) Material: Solid-surface or natural quartz surface.
 - 2) Height to Rim: [Standard][Accessible in accordance with ICC A117.1]<Insert height>.
 - 3) Color or Finish: [Not applicable]<Insert if required>.
 - 4) Number of Bowls or User Stations: [One][Two][Three][Four]<Insert number>.
 - 5) Bowl Shape: [Trough][Edge][Oval][Round][Square][Rectangular]<Insert shape>.
 - 6) Drain: Grid with NPS 1-1/2 (DN 40) tailpiece, each bowl.
 - g. Apron: [Not required][Required, with access panel].
 - h. Faucets:
 - 1) Type: Manufacturer's standard, chrome-plated solid brass, each bowl/station.
 - 2) Control: [Manual, push-button][Hardwired, control-voltage, sensor-actuated][Battery-powered, sensor-actuated]<Insert type> actuation with [pressure-balancing][thermostatic] mixing valve, and having check stops for each bowl or user station.

- i. Soap Dispensers: **[Not required][Bracket only][Manual][Hardwired, control-voltage, sensor-actuated][Battery-powered, sensor-actuated][, liquid][, foam][, powdered]<Insert type>** dispenser for each user station.
 - j. Mounting: **[Manufacturer's wall-mounting bracket][and/or][commercial floor-mounted carrier]<Insert type>**.
 - k. Supply Fittings:
 - 1) Piping: **NPS 1/2 (DN 15)** copper tubing, each bowl.
 - 2) Valves: Shutoff valve on each supply.
 - 3) Supply Piping: From wall.
 - l. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Trap and Drain Piping: **NPS 1-1/2 (DN 40)**, each bowl.
2. Wash Fountains, Linear Receptor - Stainless Steel :
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Aqua Design Manufacturing]**
 - 3) **[Bradley Corporation]**
 - 4) **[Willoughby Industries, Inc.]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Acorn Engineering Company; a Division of Morris Group International]**
 - 2) **[Aqua Design Manufacturing]**
 - 3) **[Bradley Corporation]**
 - 4) **[Willoughby Industries, Inc.]**
 - 5) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain wash fountains from single source from single manufacturer.
 - d. Standards:
 - 1) ASME A112.18.1/CSA B125.1.
 - 2) ASME A112.19.3/CSA B45.4.
 - 3) NSF 61.
 - 4) NSF 372.
 - 5) Uniform Plumbing Code, International Plumbing Code, and UL GREENGUARD certified.
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - f. Bowl(s) and Counter:
 - 1) Material: Stainless steel.
 - 2) Height to Rim: **[Standard][Accessible in accordance with ICC A117.1]<Insert height>**.

- 3) Color or Finish: **[Not applicable]<Insert if required>**.
 - 4) Number of Bowls or User Stations: **[One][Two][Three][Four]<Insert number>**.
 - 5) Bowl Shape: **[Trough][Oval][Round]<Insert shape>**.
 - 6) Drain: Grid with **NPS 1-1/2 (DN 40)** tailpiece, each bowl.
- g. Apron: **[Not required][Required, with access panel]**.
- h. Faucets:
- 1) Type: Manufacturer's standard, chrome-plated solid brass, each bowl/station.
 - 2) Control: **[Manual, push-button][Hardwired, control-voltage, sensor-actuated][Battery-powered, sensor-actuated]<Insert type>** actuation with **[pressure-balancing][thermostatic]** mixing valve, and having check stops for each bowl or user station.
- i. Soap Dispensers: **[Not required][Bracket only][Manual][Hardwired, control-voltage, sensor-actuated][Battery-powered, sensor-actuated][, liquid][, foam][, powered]<Insert type>** dispenser for each user station.
- j. Mounting: **[Manufacturer's wall-mounting bracket][and/or][commercial floor-mounted carrier]<Insert type>**.
- k. Supply Fittings:
- 1) Piping: **NPS 1/2 (DN 15)** copper tubing, each bowl.
 - 2) Valves: Shutoff valve on each supply.
 - 3) Supply Piping: From wall.
- l. Waste Fittings:
- 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Trap and Drain Piping: **NPS 1-1/2 (DN 40)**, each bowl.

2.8 FLUSHOMETER VALVES

A. Flushometer Valves, Manually Operated:

1. Flushometer Valves, Manually Operated - Diaphragm, Lever Handle :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Advanced Modern Technologies Corporation - AMTC]**
 - 2) **[American Standard]**
 - 3) **[Delany Products]**
 - 4) **[I-Con Systems, Inc.]**
 - 5) **[Sloan Valve Company]**
 - 6) **[Zurn Industries, LLC]**
 - 7) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Advanced Modern Technologies Corporation - AMTC]**

- 2) [American Standard]
 - 3) [Delany Products]
 - 4) [I-Con Systems, Inc.]
 - 5) [Sloan Valve Company]
 - 6) [Zurn Industries, LLC]
 - 7) <Insert manufacturer's name>
- c. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
 - d. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
 - e. Minimum Pressure Rating: **125 psig (860 kPa)**.
 - f. Features: Include integral check stop and backflow-prevention device.
 - g. Material: Brass body with corrosion-resistant components.
 - h. Style: Exposed.
 - i. Flushometer-Valve Finish: Chrome-plated.
 - j. Handle Finish: **[Chrome plated][Antimicrobial]**.
 - k. Consumption: [0.125 gal. (0.5 L)][0.5 gal. (1.9 L)][1.0 gal. (3.8 L)][1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)][**Dual flush 1.1 gal. (4.2 L)/1.28 gal. (4.8 L)[Dual flush 1.1 gal. (4.2 L)/1.6 gal. (6 L)]**<Insert value> per flush.
 - l. Minimum Inlet: **[NPS 3/4 (DN 20)][NPS 1 (DN 25)]**.
 - m. Minimum Outlet: **[NPS 3/4 (DN 20)][NPS 1-1/4 (DN 32)]**.
2. Flushometer Valves, Manually Operated - Piston, Lever Handle :
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) [American Standard]
 - 2) [Delany Products]
 - 3) [I-Con Systems, Inc.]
 - 4) [Kohler Co]
 - 5) [Sloan Valve Company]
 - 6) [TOTO USA, INC]
 - 7) [Zurn Industries, LLC]
 - 8) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) [American Standard]
 - 2) [Delany Products]
 - 3) [I-Con Systems, Inc.]
 - 4) [Kohler Co]
 - 5) [Sloan Valve Company]
 - 6) [TOTO USA, INC]
 - 7) [Zurn Industries, LLC]
 - 8) <Insert manufacturer's name>
 - c. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
 - d. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
 - e. Minimum Pressure Rating: **125 psig (860 kPa)**.
 - f. Features: Include integral check stop and backflow-prevention device.
 - g. Material: Brass body with corrosion-resistant components.
 - h. Style: Exposed.

- i. Flushometer-Valve Finish: Chrome-plated.
- j. Handle Finish: **[Chrome-plated][Antimicrobial]**.
- k. Consumption: **[0.125 gal. (0.5 L)][0.5 gal. (1.9 L)][1.0 gal. (3.8 L)][1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)]<Insert value>** per flush.
- l. Minimum Inlet: **[NPS 3/4 (DN 20)][NPS 1 (DN 25)]**.
- m. Minimum Outlet: **[NPS 3/4 (DN 20)][NPS 1-1/4 (DN 32)]**.

B. Flushometer Valves, Sensor Operated:

1. Flushometer Valves, Sensor Operated - Diaphragm :

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Advanced Modern Technologies Corporation - AMTC]**
 - 2) **[Delany Products]**
 - 3) **[I-Con Systems, Inc.]**
 - 4) **[Sloan Valve Company]**
 - 5) **[Zurn Industries, LLC]**
 - 6) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Advanced Modern Technologies Corporation - AMTC]**
 - 2) **[Delany Products]**
 - 3) **[I-Con Systems, Inc.]**
 - 4) **[Sloan Valve Company]**
 - 5) **[Zurn Industries, LLC]**
 - 6) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
- d. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
- e. Minimum Pressure Rating: **125 psig (860 kPa)**.
- f. Features: Include integral check stop and backflow-prevention device.
- g. Material: Brass body with corrosion-resistant components.
- h. Style: **[Exposed][Concealed]**.
- i. Exposed Flushometer-Valve Finish: Chrome-plated.
- j. Panel Finish: Chrome-plated or stainless steel.
- k. Actuator: Side or top mounted; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
- l. Trip Mechanism: **[Battery-powered][Hardwired, control-voltage]** electronic sensor; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
- m. Consumption: **[0.125 gal. (0.5 L)][0.5 gal. (1.9 L)][1.0 gal. (3.8 L)][1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)]<Insert value>** per flush.
- n. Minimum Inlet: **[NPS 3/4 (DN 20)][NPS 1 (DN 25)]**.
- o. Minimum Outlet: **[NPS 3/4 (DN 20)][NPS 1-1/4 (DN 32)]**.

2. Flushometer Valves, Sensor Operated - Piston, Hardwired :

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) [American Standard]
- 2) [Hydrotek International, Inc.]
- 3) [I-Con Systems, Inc.]
- 4) [Moen Incorporated]
- 5) [Sloan Valve Company]
- 6) [Stern Engineering Ltd.]
- 7) [Zurn Industries, LLC]
- 8) <Insert manufacturer's name>

- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) [American Standard]
- 2) [Hydrotek International, Inc.]
- 3) [I-Con Systems, Inc.]
- 4) [Moen Incorporated]
- 5) [Sloan Valve Company]
- 6) [Stern Engineering Ltd.]
- 7) [Zurn Industries, LLC]
- 8) <Insert manufacturer's name>

- c. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
- d. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
- e. Minimum Pressure Rating: **125 psig (860 kPa)**.
- f. Features: Include integral check stop and backflow-prevention device.
- g. Material: Brass body with corrosion-resistant components.
- h. Style: [**Exposed**][**Concealed**].
- i. Exposed Flushometer-Valve Finish: Chrome-plated.
- j. Panel Finish: Chrome-plated or stainless steel.
- k. Trip Mechanism: Hardwired, control-voltage electronic sensor; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
- l. Consumption: [**0.125 gal. (0.5 L)**][**0.5 gal. (1.9 L)**][**1.0 gal. (3.8 L)**][**1.1 gal. (4.2 L)**][**1.28 gal. (4.8 L)**][**1.6 gal. (6 L)**][**Dual flush 1.1 gal. (4.2 L)/1.28 gal. (4.8 L)**][**Dual flush 1.1 gal. (4.2 L)/1.6 gal. (6 L)**][<Insert value> per flush.
- m. Minimum Inlet: [**NPS 3/4 (DN 20)**][**NPS 1 (DN 25)**].
- n. Minimum Outlet: [**NPS 3/4 (DN 20)**][**NPS 1-1/4 (DN 32)**].

C. Flushometer Valves, Sensor Operated - Piston, Battery Powered :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Standard]
 - b. [Hydrotek International, Inc.]
 - c. [I-Con Systems, Inc.]
 - d. [Kohler Co]
 - e. [Moen Incorporated]
 - f. [Sloan Valve Company]

- g. [Stern Engineering Ltd.]
 - h. [TOTO USA, INC]
 - i. [Zurn Industries, LLC]
 - j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Standard]
 - b. [Hydrotek International, Inc.]
 - c. [I-Con Systems, Inc.]
 - d. [Kohler Co]
 - e. [Moen Incorporated]
 - f. [Sloan Valve Company]
 - g. [Stern Engineering Ltd.]
 - h. [TOTO USA, INC]
 - i. [Zurn Industries, LLC]
 - j. <Insert manufacturer's name>
3. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
4. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
5. Minimum Pressure Rating: **125 psig (860 kPa)**.
6. Features: Include integral check stop and backflow-prevention device.
7. Material: Brass body with corrosion-resistant components.
8. Style: [**Exposed**][**Concealed**].
9. Exposed Flushometer-Valve Finish: Chrome plated.
10. Panel Finish: Chrome-plated or stainless steel.
11. Trip Mechanism: Battery-powered electronic sensor; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
12. Consumption: [0.125 gal. (0.5 L)][0.5 gal. (1.9 L)][1.0 gal. (3.8 L)][1.1 gal. (4.2 L)][1.28 gal. (4.8 L)][1.6 gal. (6 L)][**Dual flush 1.1 gal. (4.2 L)/1.28 gal. (4.8 L)**][**Dual flush 1.1 gal. (4.2 L)/1.6 gal. (6 L)**]<Insert value> per flush.
13. Minimum Inlet: [NPS 3/4 (DN 20)][NPS 1 (DN 25)].
14. Minimum Outlet: [NPS 3/4 (DN 20)][NPS 1-1/4 (DN 32)].

2.9 TOILET SEATS

A. Toilet Seats - Commercial :

1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
- a. [American Standard]
 - b. [Bemis Manufacturing Company]
 - c. [Centoco Manufacturing Corporation]
 - d. [Church Seats; Bemis Manufacturing Company]
 - e. [Jones Stephens Corp.]
 - f. [Kohler Co]
 - g. [ProFlo; a Ferguson Enterprises, Inc. brand]
 - h. [TOTO USA, INC]
 - i. [Zurn Industries, LLC]

- j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Standard]
 - b. [Bemis Manufacturing Company]
 - c. [Centoco Manufacturing Corporation]
 - d. [Church Seats; Bemis Manufacturing Company]
 - e. [Jones Stephens Corp.]
 - f. [Kohler Co]
 - g. [ProFlo; a Ferguson Enterprises, Inc. brand]
 - h. [TOTO USA, INC]
 - i. [Zurn Industries, LLC]
 - j. <Insert manufacturer's name>
3. Source Limitations: Obtain toilet seat from single source from single manufacturer.
4. Standard: IAPMO/ANSI Z124.5.
5. Material: Plastic.
6. Type: Commercial (heavy duty).
7. Shape: [Elongated rim, open front][Elongated rim, closed front]<Insert shape>.
8. Hinge: [Check][Self-sustaining, check].
9. Hinge Material: Noncorroding metal.
10. Seat Cover: [Required][Not required].
11. Color: [White]<Insert color>.
12. Surface Treatment: [Antimicrobial][Not required].

2.10 FIXTURE CARRIERS

A. Fixture Carriers - Lavatory :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]

g. <Insert manufacturer's name>

3. Source Limitations: Obtain lavatory carriers from single source from single manufacturer.

4. Standards:

a. ASME A112.6.1M.

b. ASME A112.6.2.

B. Fixture Carriers - Sink :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

a. **[Jay R. Smith Mfg Co; a division of Morris Group International]**

b. **[Josam Company]**

c. **[MIFAB, Inc]**

d. **[Wade; a subsidiary of McWane Inc.]**

e. **[WATTS; A Watts Water Technologies Company]**

f. **[Zurn Industries, LLC]**

g. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

a. **[Jay R. Smith Mfg Co; a division of Morris Group International]**

b. **[Josam Company]**

c. **[MIFAB, Inc]**

d. **[Wade; a subsidiary of McWane Inc.]**

e. **[WATTS; A Watts Water Technologies Company]**

f. **[Zurn Industries, LLC]**

g. <Insert manufacturer's name>

3. Source Limitations: Obtain sink carriers from single source from single manufacturer.

4. Standards:

a. ASME A112.6.1M.

b. ASME A112.6.2.

C. Fixture Carriers - Urinal :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

a. **[Jay R. Smith Mfg Co; a division of Morris Group International]**

b. **[Josam Company]**

c. **[MIFAB, Inc]**

d. **[Wade; a subsidiary of McWane Inc.]**

e. **[WATTS; A Watts Water Technologies Company]**

f. **[Zurn Industries, LLC]**

g. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Jay R. Smith Mfg Co; a division of Morris Group International]**
 - b. **[Josam Company]**
 - c. **[MIFAB, Inc]**
 - d. **[Wade; a subsidiary of McWane Inc.]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain urinal carriers from single source from single manufacturer.
4. Standard: ASME A112.6.1M.
5. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings, gaskets, and feet; bolts and hardware matching fixture. **[Include additional extension coupling, faceplate, and feet for installation in wide pipe space.]**

D. Fixture Carriers - Water Closet :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Jay R. Smith Mfg Co; a division of Morris Group International]**
 - b. **[MIFAB, Inc]**
 - c. **[Wade; a subsidiary of McWane Inc.]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Jay R. Smith Mfg Co; a division of Morris Group International]**
 - b. **[MIFAB, Inc]**
 - c. **[Wade; a subsidiary of McWane Inc.]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain water closet carriers from single source from single manufacturer.
4. Standard: ASME A112.6.1M.
5. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings, gaskets, and feet; bolts and hardware matching fixture. **[Include additional extension coupling, faceplate, and feet for installation in wide pipe space.]**

E. Fixture Carriers - Wash Fountain :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
3. Source Limitations: Obtain wash fountain carriers from single source from single manufacturer.
4. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water-supply piping and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.
- B. Examine walls and floors for suitable conditions where plumbing fixtures will be installed.
- C. Examine counters for suitable conditions where lavatories and sinks will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF COMMERCIAL PLUMBING FIXTURES

- A. Lavatory Installation:
 1. Install lavatories level and plumb in accordance with roughing-in drawings.
 2. Install supports, affixed to building substrate, for wall-mounted lavatories.
 3. Install accessible, wall-mounted lavatories at mounting height in accordance with ICC A117.1.
 4. Install water-supply piping with stop on each supply to each lavatory faucet. Install stops in locations that are accessible for ease of operation.
 5. Install trap and waste piping on each drain outlet of each lavatory to be connected to sanitary drainage system.
 6. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon

- requirements specified in Section 220500 "Common Work Results for Plumbing."
7. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
 8. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."
- B. Shower Installation:
1. Assemble shower components in accordance with manufacturers' written instructions.
 2. Install showers level and plumb in accordance with roughing-in drawings.
 3. Install ball[**or gate**] valves in water-supply piping to the shower if supply stops are specified with the shower valve. Comply with ball[**or gate**] valve requirements specified in Section 220523 "General Duty Valves for Plumbing Piping." Install valves in locations that are accessible for ease of operation.
 4. Install shower flow-control fittings with specified maximum flow rates in shower arms.
 5. Set [**shower receptors**][and][**shower basins**] in leveling bed of cement grout.
 6. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
 7. Showers, except Cast-Polymer Showers: Seal joints between showers, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
 8. Cast-Polymer Showers: Adhere panels to drywall using shower manufacturer's recommended adhesive. Seal joints, between panels and between panels and adjacent drywall, using shower manufacturer's recommended caulking specific for each application. Match sealant to fixture color.
- C. Sink Installation:
1. Install sinks level and plumb in accordance with roughing-in drawings.
 2. Install supports, affixed to building substrate, for wall-mounted sinks.
 3. Install accessible, wall-mounted sinks at mounting height in accordance with ICC A117.1.
 4. Set floor-mounted sinks in leveling bed of cement grout.
 5. Install water-supply piping with stop on each supply to each sink faucet.
 - a. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 220523 "General Duty Valves for Plumbing Piping."
 - b. Install stops/valves in locations that are accessible for ease of operation.
 6. Install trap and waste piping on each drain outlet of each sink to be connected to sanitary drainage system.
 7. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
 8. Seal joints between sinks, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
 9. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."
- D. Urinal Installation:
1. Install urinals level and plumb in accordance with roughing-in drawings.
 2. Install wall-hung, back-outlet urinals onto waste-fitting seals and attached to supports.

3. Install wall-hung, bottom-outlet urinals with tubular waste piping attached to supports.
4. Install accessible, wall-mounted urinals at mounting height in accordance with ICC A117.1.
5. Install trap-seal liquid in waterless urinals.
6. Install supports, affixed to building substrate, for wall-hung urinals.
7. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
8. Use carriers without waste fitting for urinals with tubular waste piping.
9. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.
10. Measure support height installation from finished floor, not structural floor.
11. Install flushometer-valve, water-supply fitting on each supply to each urinal.
12. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
13. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
14. Install actuators in locations easily reachable for people with disabilities.
15. Install new batteries in battery-powered, electronic-sensor mechanisms.
16. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Install deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
17. Seal joints between urinals, walls, and floors using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to urinal color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

E. Water Closet Installation:

1. Install water closets level and plumb in accordance with roughing-in drawings.
2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
3. Install accessible, wall-mounted water closets at mounting height in accordance with ICC A117.1.
4. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
5. Use carrier supports with waste-fitting assembly and seal.
6. Install floor-mounted, back-outlet water closets, attached to building floor substrate, onto waste-fitting seals; and attach to support.
7. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals, and affix to building substrate.
8. Measure support height installation from finished floor, not structural floor.
9. Install flushometer-valve, water-supply fitting on each supply to each water closet.
10. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
11. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
12. Install actuators in locations easily reachable for people with disabilities.
13. Install new batteries in battery-powered, electronic-sensor mechanisms.
14. Install toilet seats on water closets.
15. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Install deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
16. Seal joints between water closets, walls, and floors using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to water-closet color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

F. Wash Fountain Installation:

1. Install wash fountains level and plumb in accordance with roughing-in drawings.
2. Set freestanding wash fountains on floor.
3. Install off-floor carrier supports, affixed to building substrate, for wall-mounted wash fountains.
4. Install accessible, wall-mounted wash fountains at mounting height in accordance with ICC A117.1.

5. Install water-supply piping with shutoff valve on each supply to each wash fountain faucet. Use ball or gate valves if supply stops are not specified with wash fountain. Comply with valve requirements specified in Section 220523 "General Duty Valves for Plumbing Piping." Install stops/valves in locations that are accessible for ease of operation.
6. Install trap and waste piping on each drain outlet of each wash fountain to be connected to sanitary drainage system.
7. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
8. Seal joints between wash fountains, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
9. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 INSTALLATION OF PIPING CONNECTIONS

- A. Connect plumbing fixtures with water supplies and soil, waste, and vent piping. Use size fittings required to match plumbing fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil, waste, and vent piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Install protective-shielding pipe covers and enclosures on exposed supplies and waste piping of accessible plumbing fixtures. Comply with requirements in Section 220719 "Plumbing Piping Insulation."
- E. Where installing piping adjacent to water closets and urinals, allow space for service and maintenance.

3.4 INSTALLATION OF ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert dimensions> high.

3.5 INSTALLATION OF CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 ADJUSTING

- A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning plumbing fixtures, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.
- C. Adjust water pressure at shower valves to produce proper flow.
- D. Adjust water pressure at flushometer valves to produce proper flow.
- E. Install new batteries in battery-powered, electronic-sensor mechanisms.

3.7 CLEANING AND PROTECTION

- A. After completing installation of plumbing fixtures, inspect and repair damage to finishes. Replace any fixtures unable to be repaired to the satisfaction of the **[Architect][Owner]**.
- B. Clean plumbing fixtures and associated faucets, valves, flushometer valves, and fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed plumbing fixtures and associated faucets, valves, flushometer valves, and fittings.
- D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 42 00 00



Task	Specification	Specification Description
22 42 13 00	22 42 00 00	Commercial Plumbing Fixtures
22 42 13 13	22 42 00 00	Commercial Plumbing Fixtures
22 42 13 13	22 45 00 00	Emergency Plumbing Fixtures
22 42 13 16	22 42 00 00	Commercial Plumbing Fixtures
22 42 13 16	22 45 00 00	Emergency Plumbing Fixtures
22 42 16 00	22 42 00 00	Commercial Plumbing Fixtures
22 42 16 13	22 42 00 00	Commercial Plumbing Fixtures
22 42 16 13	22 45 00 00	Emergency Plumbing Fixtures
22 42 16 16	22 42 00 00	Commercial Plumbing Fixtures
22 42 16 16	22 45 00 00	Emergency Plumbing Fixtures
22 42 19 00	10 28 19 00	Tub and Shower Enclosures
22 42 19 00	22 42 00 00	Commercial Plumbing Fixtures
22 42 19 00	22 45 00 00	Emergency Plumbing Fixtures
22 42 23 00	22 42 00 00	Commercial Plumbing Fixtures
22 42 23 00	22 45 00 00	Emergency Plumbing Fixtures
22 42 26 00	22 42 00 00	Commercial Plumbing Fixtures
22 42 33 00	22 42 00 00	Commercial Plumbing Fixtures
22 42 33 00	22 45 00 00	Emergency Plumbing Fixtures
22 42 39 00	22 42 00 00	Commercial Plumbing Fixtures
22 42 39 00	22 45 00 00	Emergency Plumbing Fixtures
22 42 43 00	22 42 00 00	Commercial Plumbing Fixtures
22 42 43 00	22 45 00 00	Emergency Plumbing Fixtures
22 42 46 00	22 42 00 00	Commercial Plumbing Fixtures
22 42 46 00	22 45 00 00	Emergency Plumbing Fixtures



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 43 00 00 - HEALTHCARE PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Healthcare water closets.
2. Flushometer valves.
3. Toilet seats.
4. Patient care units.
5. Healthcare showers.
6. Healthcare shower valves.
7. Healthcare bathing units.
8. Bedpan washers.
9. Bedpan washing equipment.
10. Clinic sinks.
11. Plaster sinks.
12. Scrub sinks.
13. Sink faucets.
14. Laminar-flow, faucet-spout outlets.
15. Hydrotherapy whirlpools.
16. Outlet boxes.
17. Morgue equipment.
18. Supports.
19. Supply fittings.
20. Waste fittings.
21. Grout.

B. Related Requirements:

1. Section 224100 "Residential Plumbing Fixtures" for residential plumbing fixtures for use in healthcare facilities, but not requiring special healthcare fixture attributes.
2. Section 224213.13 "Commercial Water Closets" for conventional water closets, flushometer valves, carriers, and seats for use healthcare facilities, but not requiring special healthcare fixture attributes.
3. Section 224213.16 "Commercial Urinals" for urinals for use in healthcare facilities.
4. Section 224216.13 "Commercial Lavatories" for lavatories for use in healthcare facilities, but not requiring special healthcare fixture attributes.
5. Section 224216.16 "Commercial Sinks" for sinks for use in healthcare facilities, but not requiring special healthcare fixture attributes.
6. Section 224200 "Commercial Plumbing Fixtures" for showers for use in healthcare facilities, but not requiring special healthcare fixture attributes.
7. Section 224500 "Emergency Plumbing Fixtures" for emergency showers and eye-wash units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fixtures.

2. Rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

1. Product Data: For water consumption.
2. Plumbing Fixtures: Provide the following:
 - a. Manufacturer cut sheet indicating water consumption.
 - b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.
3. Plumbing Fixtures: Provide the following:
 - a. Manufacturer cut sheet indicating water consumption.
 - b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For plumbing fixtures and faucets.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Servicing and adjustments of **[flushometer valves][electronic sensors][healthcare bathing units][bedpan washer/sanitizers][hydrotherapy whirlpools][and][morgue equipment]**.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to **[10]<Insert number>** percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to **[5]<Insert number>** percent of amount of each type and size installed.
3. Flushometer-Valve Repair Kits: Equal to **[10]<Insert number>** percent of amount of each type installed, but no fewer than **[one][six]<Insert number>** of each type.
4. Toilet Seats: Equal to **[5]<Insert number>** percent of amount of each type installed.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each product type from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A112.19.2/CSA B45.1 for vitreous-china plumbing fixtures.
- B. Comply with ASME A112.19.3/CSA B45.4 for stainless steel plumbing fixtures.
- C. Comply with ASSE 1037/ASME A112.1037/CSA B125.37 for flush valves.
- D. Comply with ASME A112.19.5/CSA B45.15 for flush valves and spuds for water closets.
- E. Comply with ASME A112.18.1/CSA B125.1 for plumbing supply fittings.
- F. Comply with ASME A112.18.2/CSA B125.2 for plumbing waste fittings.
- G. Comply with IAPMO Z124.5 for water-closet (toilet) seats.
- H. Comply with ASME A112.6.1M for plumbing fixture supports.
- I. Comply with ASSE 1016/ASME A112.1016/CSA B125.16 for shower valves.
- J. Comply with ICC A117.1 for ADA-compliant, accessible plumbing fixtures and installation.
- K. Comply with ASTM A1045 for flexible PVC gaskets used in connection of vitreous-china water closets to sanitary drainage systems.
- L. Comply with ASME A112.4.3 for plastic fittings used in connection of vitreous-china water closets to sanitary drainage systems.
- M. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- N. Faucets and bubblers intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), with requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61/NSF 372 or are certified in compliance with NSF 61/NSF 372 by an ANSI-accredited third-party certification body, that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.3 HEALTHCARE WATER CLOSETS

- A. Healthcare Water Closets, Wall Mounted - Vitreous China: .
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Standard]**
 - b. **[Crane Plumbing, LLC; a division of American Standard]**
 - c. **[Kohler Co]**
 - d. **[Sloan Valve Company]**
 - e. **[TOTO USA, INC]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Crane Plumbing, LLC; a division of American Standard]**
 - c. **[Kohler Co]**
 - d. **[Sloan Valve Company]**
 - e. **[TOTO USA, INC]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**
3. Bowl:
 - a. Material: Vitreous china.
 - b. Type: Siphon jet.
 - c. Style: **[Flushometer valve][Tank type]**.
 - d. Height: **[Standard][Accessible in accordance with ICC A117.1]**.
 - e. Rim Contour: Elongated with bedpan lugs or slots.
 - f. Water Consumption: **[1.28 gal. (4.8 L)][1.6 gal. (6.0 L)][1.6/1.1 gpm (7.2/5.0 L) dual flush]** per flush.
 - g. Spud: **NPS 1-1/2 (DN 40), [top][back]**.
4. Flushometer Valve: **<Insert flushometer-valve designation>**.
5. Toilet Seat: **<Insert toilet-seat designation>**.
6. Water-Closet Support: **[Water-closet carrier]<Insert carrier>**.
7. Water-Closet Mounting Height: **[Standard][Child][ADA compliant]**.

B. Healthcare Water Closets, Floor Mounted - Vitreous China: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Crane Plumbing, LLC; a division of American Standard]**
 - c. **[Kohler Co]**
 - d. **[Sloan Valve Company]**
 - e. **[TOTO USA, INC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Crane Plumbing, LLC; a division of American Standard]**
 - c. **[Kohler Co]**
 - d. **[Sloan Valve Company]**
 - e. **[TOTO USA, INC]**
 - f. **<Insert manufacturer's name>**

3. Bowl:

- a. Material: Vitreous china.
 - b. Type: Siphon jet.
 - c. Style: **[Flushometer valve][Tank type]**.
 - d. Height: **[Standard][Accessible in accordance with ICC A117.1]**.
 - e. Rim Contour: Elongated with bedpan lugs or slots.
 - f. Water Consumption: **[1.28 gal. (4.8 L)][1.6 gal. (6.0 L)][1.6/1.1 gpm (7.2/5.0 L/min.) dual flush]** per flush.
 - g. Outlet: **[Floor][Back]**.
 - h. Spud: **NPS 1-1/2 (DN 40), [top][back]**.
 4. Flushometer Valve: **<Insert flushometer-valve designation>**.
 5. Toilet Seat: **<Insert toilet-seat designation>**.
- C. Healthcare Water Closets, Bariatric - Vitreous China: .
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Crane Plumbing, LLC; a division of American Standard]**
 - c. **[Sloan Valve Company]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Crane Plumbing, LLC; a division of American Standard]**
 - c. **[Sloan Valve Company]**
 - d. **<Insert manufacturer's name>**
 3. Bowl:
 - a. Material: Vitreous china.
 - b. Type: Siphon jet.
 - c. Style: **[Flushometer valve][Tank type][Dual flush]**.
 - d. Height: **[Standard][Accessible in accordance with ICC A117.1]**.
 - e. Mounting: **[Floor][Wall]**.
 - f. Outlet: **[Bottom][Back]**.
 - g. Rim Contour: Elongated with bedpan lugs or slots.
 - h. Water Consumption: **[1.28 gal. (4.8 L)][Dual flush][1.6/1.1 gpm (7.2/5.0 L/min.) dual flush]<Insert drawing designation>** per flush.
 - i. Spud: **NPS 1-1/2 (DN 40), [top][back]**.
 4. Flushometer Valve: **<Insert flushometer-valve designation>**.
 5. Toilet Seat: **<Insert toilet-seat designation>**.
- D. Healthcare Water Closets, Bariatric - Stainless Steel: .
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [Whitehall Manufacturing; a division of Morris Group International]
 - b. [Willoughby Industries, Inc.]
 - c. [Zurn Industries, LLC]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Whitehall Manufacturing; a division of Morris Group International]
 - b. [Willoughby Industries, Inc.]
 - c. [Zurn Industries, LLC]
 - d. <Insert manufacturer's name>
3. Bowl:
 - a. Material: Stainless steel.
 - b. Finish: [Satin][Powder coated].
 - c. Type: Siphon jet.
 - d. Style: [Flushometer valve][Tank type].
 - e. Height: [Standard][Accessible in accordance with ICC A117.1].
 - f. Mounting: [Floor][Wall].
 - g. Outlet: [Bottom][Back].
 - h. Rim Contour: Elongated with bedpan lugs or slots.
 - i. Water Consumption: [1.28 gal. (4.8 L)][1.6/1.1 gpm (7.2/5.0 L/min.) dual flush] per flush.
 - j. Spud: NPS 1-1/2 (DN 40), [top][back].
4. Flushometer Valve: <Insert flushometer-valve designation>.
5. Toilet Seat: <Insert toilet-seat designation>.

2.4 FLUSHOMETER VALVES

A. Lever-Handle, Diaphragm Flushometer Valves: .

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Standard]
 - b. [Delany Products]
 - c. [Sloan Valve Company]
 - d. [Wolverine Brass, Inc]
 - e. [Zurn Industries, LLC]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Standard]
 - b. [Delany Products]
 - c. [Sloan Valve Company]
 - d. [Wolverine Brass, Inc]

- e. **[Zurn Industries, LLC]**
- f. **<Insert manufacturer's name>**
- 3. Minimum Pressure Rating: **125 psig (860 kPa)**.
- 4. Features: Integral check stop, backflow-prevention device, and outlet-tube-mounted bedpan washer.
- 5. Material: Brass body with corrosion-resistant components.
- 6. Exposed Flushometer-Valve Finish: Chrome plated.
- 7. Style: Exposed.
- 8. Consumption: **[1.28 gal. (4.8 L)][1.6 gal. (6 L)][3.5 gal. (13.2 L)][1.6/1.1 gpm (7.2/5.0 L/min.) dual flush]<Insert value>** per flush.
- 9. Minimum Inlet: **NPS 1 (DN 25)**.
- 10. Minimum Outlet: **NPS 1-1/4 (DN 32)**, extended length.

2.5 TOILET SEATS

A. Toilet Seats: **<Insert designation>**.

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Bemis Manufacturing Company]**
 - c. **[Centoco Manufacturing Corporation]**
 - d. **[Church Seats; Bemis Manufacturing Company]**
 - e. **[Kohler Co]**
 - f. **[Olsonite; Bemis Manufacturing Company]**
 - g. **[TOTO USA, INC]**
 - h. **[Zurn Industries, LLC]**
 - i. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Bemis Manufacturing Company]**
 - c. **[Centoco Manufacturing Corporation]**
 - d. **[Church Seats; Bemis Manufacturing Company]**
 - e. **[Kohler Co]**
 - f. **[Olsonite; Bemis Manufacturing Company]**
 - g. **[TOTO USA, INC]**
 - h. **[Zurn Industries, LLC]**
 - i. **<Insert manufacturer's name>**
- 3. Material: Plastic with antimicrobial agent.
- 4. Type: Commercial **[(standard)][(heavy duty)]**.
- 5. Shape: Elongated rim, open front.
- 6. Hinge: Check.
- 7. Hinge Material: Noncorroding metal.
- 8. Color: White.

2.6 PATIENT CARE UNITS

- A. Patient Care Units, Factory Fabricated, Combination, Swing-Away, Water Closet and Lavatory Healthcare Plumbing Fixture: .
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Krowne]**
 - b. **[Metcraft Industries, Inc.]**
 - c. **[Whitehall Manufacturing; a division of Morris Group International]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Krowne]**
 - b. **[Metcraft Industries, Inc.]**
 - c. **[Whitehall Manufacturing; a division of Morris Group International]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Cabinet: Fixed installation with storage space and toilet paper holder.
 - a. Material: **[Stainless steel][Stainless steel, plastic laminate, or fiberglass]** with **[laminated-wood or -plastic][solid-plastic][stainless steel]** top surface.
 - b. Color: **[Not applicable]<Insert color>**.
 - c. Mounting: Wall bracket.
 4. Water Closet: Swivel, floor mounted, **[back][floor]** outlet.
 - a. Material: Stainless steel.
 - b. Orientation: **[Left][Right]** hand.
 - c. Seal: For outlet.
 - d. Flushometer: Concealed flushometer valve with push-button trip mechanism, check stop, and vacuum breaker on tailpiece.
 - e. Toilet Seat: White, solid plastic.
 - f. Support: Floor plate.
 5. Lavatory: Counter mounted.
 - a. Material: **[Stainless steel][Cultured marble][Solid-surface material]<Insert material>**.
 - b. Color: **[Not applicable]<Insert color>**.
 - c. Faucet: **[Gooseneck type with wrist-blade handles][Swing-spout type with single lever]<Insert type>**, laminar flow.
 - d. Waste Fittings: Grid drain, with **NPS 1-1/4 (DN 32)** tailpiece and **[NPS 1-1/4 (DN 32)][NPS 1-1/2 by NPS 1-1/4 (DN 40 by DN 32)]** chrome-plated, cast-brass P-trap; tubular-brass waste to wall; and wall flange.
- B. Patient Care Units, Factory Fabricated, Combination, Fixed Position, Water Closet and Lavatory Healthcare Fixture: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Krowne]**
 - b. **[Metcraft Industries, Inc.]**
 - c. **[Whitehall Manufacturing; a division of Morris Group International]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Krowne]**
 - b. **[Metcraft Industries, Inc.]**
 - c. **[Whitehall Manufacturing; a division of Morris Group International]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Cabinet: Fixed installation; swing-away cabinet or retractable, water-closet cover design with storage space and toilet paper holder.
 - a. Material: **[Stainless steel][Stainless steel, plastic laminate, or fiberglass]** with **[laminated-wood or -plastic][solid-plastic][stainless steel]** top surface.
 - b. Color: **[Not applicable]<Insert color>**.
 - c. Support: Wall bracket.
4. Water Closet: Floor mounted, floor outlet.
 - a. Material: Stainless steel or vitreous china.
 - b. Orientation: **[Left][Right]** hand.
 - c. Seal: For outlet.
 - d. Flushometer: Concealed flushometer valve with push-button trip mechanism, check stop, and vacuum breaker on tailpiece.
 - e. Toilet Seat: White, solid plastic.
5. Lavatory: Counter mounted.
 - a. Material: **[Stainless steel][Cultured marble][Solid-surface material]<Insert material>**.
 - b. Color: **[Not applicable]<Insert color>**.
 - c. Faucet: **[Gooseneck type with wrist-blade handles][Swing-spout type with single lever]<Insert type>**, laminar flow spout outlet.
 - d. Waste Fittings: Grid drain, with **NPS 1-1/4 (DN 32)** tailpiece and **[NPS 1-1/4 (DN 32)][NPS 1-1/2 by NPS 1-1/4 (DN 40 by DN 32)]** chrome-plated, cast-brass P-trap; tubular-brass waste to wall; and wall flange.

2.7 HEALTHCARE SHOWERS

- A. Healthcare Showers: Accessible, **[glass-fiber-reinforced plastic][acrylic]**. .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. **[Aqua Bath Company, Inc.]**
 - b. **[Clarion Bathware]**
 - c. **[Florestone Products Co., Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Aqua Bath Company, Inc.]**
 - b. **[Clarion Bathware]**
 - c. **[Florestone Products Co., Inc.]**
 - d. **<Insert manufacturer's name>**
3. Nominal Size: **[60 by 36 inches (1524 by 915 mm)]<Insert dimensions>**.
4. Surround:
- a. One piece**[or sealed, multiple piece]**.
5. Bathing Surface: Slip resistant.
6. Color: **[White]<Insert color>**.
7. Drain Location: **[Left side][Center][Right side]**.
8. Accessibility Options: Include grab bar and bench.
9. Shower Valves: **<Insert healthcare shower-valve designation>**.
10. Drain: Grid, **NPS 2 (DN 50)**.

2.8 HEALTHCARE SHOWER VALVES

A. Healthcare Shower Valves, Pressure-Balance Mixing Valve: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[American Standard]**
 - c. **[Chicago Faucets; Geberit Group]**
 - d. **[Kohler Co]**
 - e. **[Lawler Manufacturing Company, Inc]**
 - f. **[Matco-Norca]**
 - g. **[Moen Incorporated]**
 - h. **[POWERS; A Watts Water Technologies Company]**
 - i. **[Speakman Company]**
 - j. **[Symmons Industries, Inc]**
 - k. **[Zurn Industries, LLC]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Acorn Engineering Company; a Division of Morris Group International]
 - b. [American Standard]
 - c. [Chicago Faucets; Geberit Group]
 - d. [Kohler Co]
 - e. [Lawler Manufacturing Company, Inc]
 - f. [Matco-Norca]
 - g. [Moen Incorporated]
 - h. [POWERS; A Watts Water Technologies Company]
 - i. [Speakman Company]
 - j. [Symmons Industries, Inc]
 - k. [Zurn Industries, LLC]
 - l. <Insert manufacturer's name>
 3. Valve:
 - a. Body Material: Solid brass.
 - b. Finish: Polished chrome plate.
 - c. Maximum Flow Rate: [1.25 gpm (4.7 L/min.)][1.5 gpm (6.8 L/min.)][2.0 gpm (9.1 L/min.)][2.5 gpm (9.5 L/min.)]<Insert value> unless otherwise indicated.
 - d. Mounting: [Concealed][Exposed].
 - e. Operation: Single-handle, [push-pull][or][twist or rotate] control.
 - f. Antiscald Device: [Integral with mixing valve][Separate unit][Not required].
 - g. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water-supply connections.
 - h. Indicators: For hot and cold water.
 4. Shower Head:
 - a. Type: [Ball joint with arm and flange][Without ball joint, but with arm and flange][Ball joint and head integral with mounting flange][Integral with mounting flange][Handheld, slide bar mounted][Handheld, hook mounted]<Insert type>.
 - b. Shower Head Material: Metallic with chrome-plated finish.
 - c. Spray Pattern: [Adjustable][Fixed].
 - d. Integral Volume Control: [Not required][Required].
 - e. Shower-Arm, Flow-Control Fitting: [Not required][1.5 gpm (5.7 L/min.)][2.0 gpm (7.6 L/min.)].
 - f. Temperature Indicator: [Integral with faucet][Not required].
- B. Healthcare Shower Valves, Thermostatic Mixing Valve: .
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Acorn Engineering Company; a Division of Morris Group International]
 - b. [Chicago Faucets; Geberit Group]
 - c. [Lawler Manufacturing Company, Inc]
 - d. [POWERS; A Watts Water Technologies Company]
 - e. [Symmons Industries, Inc]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[Chicago Faucets; Geberit Group]**
 - c. **[Lawler Manufacturing Company, Inc]**
 - d. **[POWERS; A Watts Water Technologies Company]**
 - e. **[Symmons Industries, Inc]**
 - f. **<Insert manufacturer's name>**
3. Valve:
- a. Body Material: Solid brass.
 - b. Finish: Polished chrome plate.
 - c. Maximum Flow Rate: **[1.25 gpm (4.7 L/min.)][1.5 gpm (6.8 L/min.)][2.0 gpm (9.1 L/min.)][2.5 gpm (9.5 L/min.)]<Insert value>** unless otherwise indicated.
 - d. Mounting: **[Concealed][Exposed]**.
 - e. Operation: Single-handle, **[push-pull][or][twist or rotate]** control.
 - f. Antiscald Device: **[Integral with mixing valve][Separate unit][Not required]**.
 - g. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water-supply connections.
 - h. Indicators: For hot and cold water.
4. Shower Head:
- a. Type: **[Ball joint with arm and flange][Without ball joint, but with arm and flange][Ball joint and head integral with mounting flange][Integral with mounting flange][Handheld, slide bar mounted][Handheld, hook mounted]<Insert type>**.
 - b. Material: Metallic with chrome-plated finish.
 - c. Spray Pattern: **[Adjustable][Fixed]**.
 - d. Integral Volume Control: **[Not required][Required]**.
 - e. Shower-Arm, Flow-Control Fitting: **[Not required][1.5 gpm (5.7 L/min.)][2.0 gpm (7.6 L/min.)]**.
 - f. Temperature Indicator: **[Integral with faucet][Not required]**.

2.9 HEALTHCARE BATHING UNITS

A. Healthcare Bathing Units, Side Entry, Whirlpool: .

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arjo Inc.]**
 - b. **[Invacare Continuing Care Group]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arjo Inc.]**
 - b. **[Invacare Continuing Care Group]**
 - c. **<Insert manufacturer's name>**
- 3. Fixture: Plastic-tub, institutional bath fixture with whirlpool and integral controls.

- a. Standard: UL 1795.
- b. Tub Size: **[60 by 30 inches (1524 by 762 mm)]<Insert dimensions>**.
- c. Controls: Vacuum breakers on supplies, thermostatic mixing valve, tub fill spout, and handheld shower head.
4. Supply Connections: **[NPS 3/4 (DN 20)][NPS 1 (DN 25)]** with shutoff valve.
5. Drain: Manufacturer's standard **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]** with tailpiece.
6. Drain Piping: **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]** cast-brass P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2. Include combined drain piping if two drains.
7. Unit Electrical Characteristics:
 - a. Volts: **[120][240][277][480]<Insert number>**.
 - b. Phase(s): **[One][Three]**.
 - c. Hertz: **[60]<Insert number>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

B. Healthcare Bathing Units: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arjo Inc.]**
 - b. **[Clarion Bathware]**
 - c. **[Comfort Designs Bathware]**
 - d. **[Invacare Continuing Care Group]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arjo Inc.]**
 - b. **[Clarion Bathware]**
 - c. **[Comfort Designs Bathware]**
 - d. **[Invacare Continuing Care Group]**
 - e. **<Insert manufacturer's name>**
3. Fixture: Plastic-tub, institutional bath fixture with integral controls.
 - a. Tub Size: **[60 by 30 inches (1524 by 762 mm)]<Insert dimensions>**.
 - b. Controls: Vacuum breakers on supplies, thermostatic mixing valve, tub fill spout, and handheld shower head.
 - c. Entry: **[Side][Transfer lift][Slide on]**.
 - d. Height: **[Adjustable][Fixed]**.
4. Supply Connections: **[NPS 3/4 (DN 20)][NPS 1 (DN 25)]** with shutoff valve.
5. Drain: Manufacturer's standard **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]** with tailpiece.
6. Drain Piping: **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]** cast-brass P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2. Include combined drain piping if two drains.
7. Lift System: **[Not required]<Insert description>**.
8. Unit Electrical Characteristics:

- a. Volts: [120][240][277][480]<Insert number>.
- b. Phase(s): [One][Three].
- c. Hertz: [60]<Insert number>.
- d. Full-Load Amperes: <Insert value>.
- e. Minimum Circuit Ampacity: <Insert value>.
- f. Maximum Overcurrent Protection: <Insert amperage>.

C. Healthcare Bathing Units, Front-Entry Shower: .

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arjo Inc.]
 - b. [Comfort Designs Bathware]
 - c. [Invacare Continuing Care Group]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arjo Inc.]
 - b. [Comfort Designs Bathware]
 - c. [Invacare Continuing Care Group]
 - d. <Insert manufacturer's name>
3. Fixture: Plastic-tub, institutional fixture with integral controls.
 - a. Cabinet Size: [35 by 41 inches (889 by 1041 mm)]<Insert dimensions>.
 - b. Controls: Vacuum breakers on supplies, thermostatic mixing valve, tub fill spout, and handheld shower head.
4. Supply Connections: [NPS 3/4 (DN 20)][NPS 1 (DN 25)] with shutoff valve.
5. Drain: Manufacturer's standard NPS 2 (DN 50) with tailpiece.
6. Drain Piping: NPS 2 (DN 50) P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2. Include combined drain piping if two drains.
7. Unit Electrical Characteristics:
 - a. Volts: [120][240][277][480]<Insert number>.
 - b. Phase(s): [One][Three].
 - c. Hertz: [60]<Insert number>.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

2.10 BEDPAN WASHERS

A. Bedpan Washers, Wall Mounted: .

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the

following]:

- a. [American Standard]
 - b. [Kohler Co]
 - c. [T&S Brass and Bronze Works, Inc.]
 - d. [Whitehall Manufacturing; a division of Morris Group International]
 - e. [Zurn Industries, LLC]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Standard]
 - b. [Kohler Co]
 - c. [T&S Brass and Bronze Works, Inc.]
 - d. [Whitehall Manufacturing; a division of Morris Group International]
 - e. [Zurn Industries, LLC]
 - f. <Insert manufacturer's name>
 3. Hose Assembly: [48-inch- (1220-mm-)]<Insert dimension> long, rubber or vinyl hose with self-closing, handheld spray nozzle, wall bracket, and hook.
 4. Vacuum Breaker: ASSE 1001, atmospheric, wall mounted.
 5. Shutoff Valve: Wall-mounted, [cross-handle][foot pedal valve]<Insert type> supply stop upstream of vacuum breaker.
 6. Connecting Piping: Concealed.
 7. Finish: Polished chrome-plated finish on exposed metal parts.
 8. Supply Connection: [NPS 1/2 (DN 15)]<Insert size>.
- B. Bedpan Washers, Wall-Mounted Assembly with Foot Control: .
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Kohler Co]
 - b. [T&S Brass and Bronze Works, Inc.]
 - c. [Zurn Industries, LLC]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Kohler Co]
 - b. [T&S Brass and Bronze Works, Inc.]
 - c. [Zurn Industries, LLC]
 - d. <Insert manufacturer's name>
 3. Hose: [48-inch- (1220-mm-)]<Insert dimension> long, rubber or vinyl hose with self-closing, handheld spray nozzle, wall bracket, and hook.
 4. Vacuum Breaker: ASSE 1001, atmospheric, wall mounted.
 5. Shutoff Valve: Wall-mounted, [cross-handle]<Insert type> supply stop between foot control and vacuum breaker.
 6. Connecting Piping: Concealed.

7. Finish: Polished chrome-plated finish on exposed metal parts.
8. Control Mounting: **[Floor][Wall]**.
9. Supply Connection(s): **[NPS 1/2 (DN 15)]<Insert size>**.
10. Foot Control: **[Floor][Wall]** mounted.
11. Foot Control Type: **[Single pedal][Double pedal, hot and cold water]**,

2.11 BEDPAN WASHING EQUIPMENT

A. Bedpan Washers/Sanitizers: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[MEIKO]**
 - b. **[Rhima]**
 - c. **[Steelco S.p.A.]**
 - d. **[STERIS Corporation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[MEIKO]**
 - b. **[Rhima]**
 - c. **[Steelco S.p.A.]**
 - d. **[STERIS Corporation]**
 - e. **<Insert manufacturer's name>**
3. Fixture:
 - a. Construction: Cast-iron chamber and P-trap waste assembly with spray nozzles and **[enameled-steel][stainless steel]** front panel and cover box.
 - b. Controls: Electric, 120 V ac, automatic operation with timer, solenoid valves, and circuit breaker.
 - c. Door Mechanism: Foot-pedal operation.
4. Supply Connections: **NPS 1 (DN 25)** cold water and **NPS 3/8 (DN 10) [hot water][steam]**.
5. Drain Piping: **NPS 3 (DN 80)** P-trap and soil pipe.
6. Atmospheric Vent Connection: **NPS 2 (DN 50)**.
7. Mounting: **[Recessed][Wall]**.
8. Mounting Hardware: Matching fixture-mounting arrangement.
9. Accessories:
 - a. Bedpan Rack(s): **[One][Two]<Insert number>**.
 - b. Urinal Rack(s): **[One][Two]<Insert number>**.
 - c. Drain Tray(s): **[One][Two]<Insert number>**.

B. Bedpan Washers/Disinfectors: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Arjo Inc.]
 - b. [MEIKO]
 - c. [Rhima]
 - d. [Steelco S.p.A.]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Arjo Inc.]
 - b. [MEIKO]
 - c. [Rhima]
 - d. [Steelco S.p.A.]
 - e. <Insert manufacturer's name>
3. Fixture:
- a. Controls: Electric, automatic operation.
 - b. Cabinet: Stainless steel.
 - c. Wash Chamber: Stainless steel.
4. Supply Connections: **NPS 1/2 (DN 15)** cold water and **NPS 1/2 (DN 15)** hot water.
5. Drain Piping: **NPS 4 (DN 100)** P-trap and soil pipe.
6. Mounting: [**Freestanding**][**Wall mounted**][**Undercounter mounted**].
7. Mounting Hardware: Matching fixture-mounting arrangement.
8. Unit Electrical Characteristics:
- a. Volts: [**208**][**240**]<Insert number>.
 - b. Phase(s): [**One**][**Three**].
 - c. Hertz: [**60**]<Insert number>.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

2.12 CLINIC SINKS

A. Clinic Sinks, Wall Mounted: .

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Standard]
 - b. [Crane Plumbing, LLC; a division of American Standard]
 - c. [Kohler Co]
 - d. [Zurn Industries, LLC]
 - e. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. **[American Standard]**
- b. **[Crane Plumbing, LLC; a division of American Standard]**
- c. **[Kohler Co]**
- d. **[Zurn Industries, LLC]**
- e. **<Insert manufacturer's name>**

3. Fixture: Back-outlet, vitreous-china, blowout-type, flushing-rim, service sink.

- a. Nominal Size: **[25 by 20 inches (635 by 510 mm)]<Insert dimensions>**.
- b. Outlet Size: **[NPS 4 (DN 100)][or][NPS 3 (DN 80)]**.
- c. Color: White.
- d. Rim Guard: Stainless steel, on front.

4. Flushometer Valve: **<Insert flushometer-valve designation>**.
5. Faucet: **[Not required]<Insert sink-faucet designation>**.
6. Support: **[Type IV sink carrier]<Insert carrier>**.
7. Sink Mounting Height: **[Standard][ADA compliant]**.

B. Clinic Sinks, Floor Mounted: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[American Standard]**
- b. **[Crane Plumbing, LLC; a division of American Standard]**
- c. **[Kohler Co]**
- d. **[Zurn Industries, LLC]**
- e. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[American Standard]**
- b. **[Crane Plumbing, LLC; a division of American Standard]**
- c. **[Kohler Co]**
- d. **[Zurn Industries, LLC]**
- e. **<Insert manufacturer's name>**

3. Fixture: Bottom-outlet, vitreous-china, siphon-jet, flushing-rim, service sink.

- a. Nominal Size: **[27 by 20 inches (685 by 510 mm)]<Insert dimensions>**.
- b. Color: White.
- c. Rim Guards: Stainless steel on front.

4. Sink Base: **[10 inches (254 mm)]<Insert dimension>** high; cast terrazzo if required.
5. Flushometer Valve: **<Insert flushometer-valve designation>**.
6. Faucet: **<Insert sink-faucet designation>**.
7. Supply Fittings: Comply with requirements in "Supply Fittings" Article.

2.13 PLASTER SINKS

A. Plaster Sinks, Wall Mounted: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Standard]**
 - b. **[Crane Plumbing, LLC; a division of American Standard]**
 - c. **[Franke]**
 - d. **[Kohler Co]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Crane Plumbing, LLC; a division of American Standard]**
 - c. **[Franke]**
 - d. **[Kohler Co]**
 - e. **<Insert manufacturer's name>**
3. Fixture:
 - a. Type: Utility sink.
 - b. Material: **[Vitreous china][or][stainless steel]**.
 - c. Nominal Size: **[24 by 22 inches (610 by 560 mm)][30 by 22 inches (762 by 560 mm)]<Insert dimensions>** with back.
 - d. Color: White.
 - e. Faucet Holes: **[One][Two]** in back.
 - f. Drain: Grid, **NPS 1-1/2 (DN 40)[with NPS 1-1/2 (DN 40) to NPS 2 (DN 50) adaptor]**.
4. Faucet: **<Insert sink-faucet designation>**.
5. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
6. Drain Piping: **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]** chrome-plated brass; **0.045-inch- (1.1-mm-)** thick waste to interceptor; interceptor to wall; and wall flange complying with ASME A112.18.2/CSA B125.2.
7. Plaster Interceptor:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Jay R. Smith Mfg Co; a division of Morris Group International]**
 - 2) **[Josam Company]**
 - 3) **[MIFAB, Inc]**
 - 4) **[WATTS; A Watts Water Technologies Company]**
 - 5) **[Zurn Industries, LLC]**
 - 6) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of

the following:

- 1) [Jay R. Smith Mfg Co; a division of Morris Group International]
 - 2) [Josam Company]
 - 3) [MIFAB, Inc]
 - 4) [WATTS; A Watts Water Technologies Company]
 - 5) [Zurn Industries, LLC]
 - 6) <Insert manufacturer's name>
- c. Description: [Cast iron][or][steel body][or][ABS plastic][PE resin] and removable cover with acid-resistant-enameled interior lining and outside coating; removable, corrosion-resistant metal screens or strainer; and [NPS 1-1/2 (DN 40)][NPS 2 (DN 50)] inlet and outlet.
8. Support: [Type III sink carrier with white-enameled-steel brackets]<Insert carrier>.
 9. Sink Mounting Height: [Standard][ADA compliant].

2.14 SCRUB SINKS

A. Scrub Sinks, Stainless Steel, Wall Mounted: .

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CSI Industries Inc.]
 - b. [Elkay]
 - c. [Franke]
 - d. [Sloan Valve Company]
 - e. [Whitehall Manufacturing; a division of Morris Group International]
 - f. [Willoughby Industries, Inc.]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CSI Industries Inc.]
 - b. [Elkay]
 - c. [Franke]
 - d. [Sloan Valve Company]
 - e. [Whitehall Manufacturing; a division of Morris Group International]
 - f. [Willoughby Industries, Inc.]
 - g. <Insert manufacturer's name>
3. Fixture:
 - a. Nominal Size: [Single][Dual][Triple]<Insert number> Station <Insert width x depth dimensions> with back and faucet hole.
 - b. Drain: [Grid]<Insert type>, NPS 1-1/2 (DN 40).
4. Valve: Adjustable thermostatic controlled pressure mixing valve, one per station.
5. Faucet: Gooseneck-spout, [knee-action][or][sensor-operated][or][foot-operated] water and

- soap dispenser; laminar-flow spout outlet. <Insert sink-faucet designation>.
- 6. Waste Fittings: Comply with requirements in "Waste Fittings" Article.
- 7. Support: [Type I sink carrier][Type II sink carrier]<Insert carrier>.
- 8. Sink Mounting Height: [Standard][ADA compliant].

B. Scrub Sinks, Vitreous China, Wall Mounted: .

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Kohler Co]
 - b. [Whitehall Manufacturing; a division of Morris Group International]
 - c. [Zurn Industries, LLC]
 - d. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Kohler Co]
 - b. [Whitehall Manufacturing; a division of Morris Group International]
 - c. [Zurn Industries, LLC]
 - d. <Insert manufacturer's name>
- 3. Fixture:
 - a. Nominal Size: [28 by 22 inches (710 by 560 mm)][30 by 22 inches (762 by 560 mm)]<Insert dimensions> with back or ledge with one faucet hole.
 - b. Color: White.
 - c. Drain: [Grid]<Insert type>, NPS 1-1/2 (DN 40).
- 4. Faucet: Gooseneck-spout, [knee-action][or][sensor-operated][or][foot-operated] water and soap dispenser; laminar-flow spout outlet. <Insert sink-faucet designation>.
- 5. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
- 6. Waste Fittings: Comply with requirements in "Waste Fittings" Article.
- 7. Support: [Type I sink carrier][Type II sink carrier][Type III sink carrier]<Insert carrier>.
- 8. Sink Mounting Height: [Standard][ADA compliant].

2.15 SINK FAUCETS

A. Sink Faucets, Manual-Operation Mixing Valve: .

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Standard]
 - b. [Bradley Corporation]
 - c. [Chicago Faucets; Geberit Group]
 - d. [Delta Faucet Company]
 - e. [Elkay]
 - f. [Fisher Manufacturing Co]

- g. [GROHE America, Inc]
- h. [Kohler Co]
- i. [Krowne]
- j. [Moen Incorporated]
- k. [Speakman Company]
- l. [T&S Brass and Bronze Works, Inc.]
- m. [Zurn Industries, LLC]
- n. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [American Standard]
- b. [Bradley Corporation]
- c. [Chicago Faucets; Geberit Group]
- d. [Delta Faucet Company]
- e. [Elkay]
- f. [Fisher Manufacturing Co]
- g. [GROHE America, Inc]
- h. [Kohler Co]
- i. [Krowne]
- j. [Moen Incorporated]
- k. [Speakman Company]
- l. [T&S Brass and Bronze Works, Inc.]
- m. [Zurn Industries, LLC]
- n. <Insert manufacturer's name>

- 3. Configuration: Hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
- 4. Body Type: [Centerset][Widespread][Single hole]<Insert type>.
- 5. Body Material: Solid brass.
- 6. Finish: [Chrome plated][Polished chrome plate]<Insert finish>.
- 7. Maximum Flow Rate: [2.2 gpm (8.3 L/min.)][2.5 gpm (9.5 L/min.)]<Insert value>.
- 8. Control:

- a. [Lever][Cross, four-arm][Wrist-blade, 4-inch (102-mm)][Elbow, 6-inch (152-mm)]<Insert type> handle(s).
- b. [Foot pedal][Knee action]<Insert type>.

- 9. Mounting Type: [Deck, concealed][Deck, exposed][Back/wall, exposed]<Insert type>.
- 10. Spout Type: [Rigid][Swivel], [low profile][gooseneck]<Insert type>.
- 11. Vacuum Breaker: [Required][Not required] for hose outlet.
- 12. Spout Outlet: [Laminar flow][Hose thread][Plain end][Spray]<Insert type>.

B. Sink Faucets, Automatic, Electronic-Sensor-Operated Mixing Valve: .

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Standard]
 - b. [Chicago Faucets; Geberit Group]
 - c. [Hydrotek International, Inc.]

- d. [Kohler Co]
 - e. [Moen Incorporated]
 - f. [Sloan Valve Company]
 - g. [Speakman Company]
 - h. [T&S Brass and Bronze Works, Inc.]
 - i. [Zurn Industries, LLC]
 - j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Standard]
 - b. [Chicago Faucets; Geberit Group]
 - c. [Hydrotek International, Inc.]
 - d. [Kohler Co]
 - e. [Moen Incorporated]
 - f. [Sloan Valve Company]
 - g. [Speakman Company]
 - h. [T&S Brass and Bronze Works, Inc.]
 - i. [Zurn Industries, LLC]
 - j. <Insert manufacturer's name>
3. Configuration: Hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
 4. Body Type: [Centerset][Widespread][Single hole]<Insert type>.
 5. Body Material: Solid brass.
 6. Finish: [Polished chrome plate]<Insert finish>.
 7. Maximum Flow Rate: [2.2 gpm (8.3 L/min.)][2.5 gpm (9.5 L/min.)]<Insert value> unless otherwise indicated.
 8. Mounting Type: [Deck, concealed][Deck, exposed][Back/wall, exposed].
 9. Power Supply: [Battery powered][Hard wired].
 10. Spout Type: [Rigid][Swivel], [low profile][gooseneck]<Insert type>.
 11. Vacuum Breaker: [Required][Not required] for hose outlet.
 12. Spout Outlet: [Laminar flow][Hose thread][Plain end][Spray]<Insert type>.

2.16 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [American Standard]
2. [Chicago Faucets; Geberit Group]
3. [Delta Faucet Company.]
4. [Elkay]
5. [GROHE America, Inc]
6. [Kohler Co]
7. [Moen Incorporated]
8. [Speakman Company]
9. [T&S Brass and Bronze Works, Inc.]
10. [Zurn Industries, LLC]
11. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's

name; product name or designation> or comparable product by one of the following:

1. **[American Standard]**
2. **[Chicago Faucets; Geberit Group]**
3. **[Delta Faucet Company.]**
4. **[Elkay]**
5. **[GROHE America, Inc]**
6. **[Kohler Co]**
7. **[Moen Incorporated]**
8. **[Speakman Company]**
9. **[T&S Brass and Bronze Works, Inc.]**
10. **[Zurn Industries, LLC]**
11. **<Insert manufacturer's name>**

- C. Description: Chrome-plated brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes faucet flow.

2.17 HYDROTHERAPY WHIRLPOOLS

A. Hydrotherapy Whirlpools, Podiatry: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Whitehall Manufacturing; a division of Morris Group International]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Whitehall Manufacturing; a division of Morris Group International]**
 - b. **<Insert manufacturer's name>**
3. Description: Stationary stainless steel tank for feet and ankles.
 - a. Water Capacity: **15 gal. (57 L).**
 - b. Drain: Waste connection.
 - c. Controls.
 - d. Thermometer: Control panel or tank mounted.
 - e. One electric turbine ejector.
 - f. Unit Electrical Characteristics:
 - 1) Volts: **[120][240][277][480]<Insert number>.**
 - 2) Phase(s): **[One][Three].**
 - 3) Hertz: **[60]<Insert number>.**
 - 4) Full-Load Amperes: **<Insert value>.**
 - 5) Minimum Circuit Ampacity: **<Insert value>.**
 - 6) Maximum Overcurrent Protection: **<Insert amperage>.**

B. Hydrotherapy Whirlpools, Upper Extremity: .

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Whitehall Manufacturing; a division of Morris Group International]
 - b. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Whitehall Manufacturing; a division of Morris Group International]
 - b. <Insert manufacturer's name>
 3. Description: Stationary, pedestal-mounted, stainless steel tank for arms, hands, and elbows.
 - a. Water Capacity: **25 gal. (95 L).**
 - b. Drain: Waste connection.
 - c. One arm support.
 - d. Controls.
 - e. Thermometer: Control panel or tank mounted.
 - f. One electric turbine ejector.
 - g. Unit Electrical Characteristics:
 - 1) Volts: [120][240][277][480]<Insert number>.
 - 2) Phase(s): [One][Three].
 - 3) Hertz: [60]<Insert number>.
 - 4) Full-Load Amperes: <Insert value>.
 - 5) Minimum Circuit Ampacity: <Insert value>.
 - 6) Maximum Overcurrent Protection: <Insert amperage>.
- C. Hydrotherapy Whirlpools, High Tank, Body: .
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Whitehall Manufacturing; a division of Morris Group International]
 - b. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Whitehall Manufacturing; a division of Morris Group International]
 - b. <Insert manufacturer's name>
 3. Description: Stationary, stainless steel tank for legs, hips, and back.
 - a. Water Capacity: **105 gal. (397 L).**
 - b. Drain: Waste connection.
 - c. Controls.
 - d. Thermometer: Control panel or tank mounted.
 - e. One electric turbine ejector.

f. Unit Electrical Characteristics:

- 1) Volts: [120][240][277][480]<Insert number>.
- 2) Phases: [One][Three].
- 3) Hertz: [60]<Insert number>.
- 4) Full-Load Amperes: <Insert value>.
- 5) Minimum Circuit Ampacity: <Insert value>.
- 6) Maximum Overcurrent Protection: <Insert amperage>.

D. Hydrotherapy Whirlpools, Low Tank, Body: .

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Whitehall Manufacturing; a division of Morris Group International]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Whitehall Manufacturing; a division of Morris Group International]
 - b. <Insert manufacturer's name>
3. Description: Stationary, extended-length, stainless steel tank for legs, hips, and lower back.
 - a. Water Capacity: **105 gal. (397 L).**
 - b. Drain: Waste connection.
 - c. Controls.
 - d. Thermometer: Control panel or tank mounted.
 - e. Head rest.
 - f. One electric turbine ejector.
 - g. Unit Electrical Characteristics:
 - 1) Volts: [120][240][277][480]<Insert number>.
 - 2) Phase(s): [One][Three].
 - 3) Hertz: [60]<Insert number>.
 - 4) Full-Load Amperes: <Insert value>.
 - 5) Minimum Circuit Ampacity: <Insert value>.
 - 6) Maximum Overcurrent Protection: <Insert amperage>.

E. Hydrotherapy Whirlpools, Small Hubbard Immersion Tank: .

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Whitehall Manufacturing; a division of Morris Group International]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. **[Whitehall Manufacturing; a division of Morris Group International]**
 - b. **<Insert manufacturer's name>**
3. Description: Stationary, butterfly-shaped tank for full-body massage.
 - a. Tank Dimensions: **[93 by 64 by 22 inches (2362 by 1626 by 560 mm)]<Insert dimensions>**.
 - b. Overall Height: **[34 to 38 inches (864 to 965 mm)]<Insert dimensions>**.
 - c. Water Capacity: **[268 gal. (1014 L)]<Insert value>**.
 - d. Material: Stainless steel.
 - e. Supports: Legs or base.
 - f. Controls.
 - g. Thermometer: Control panel or tank rim mounted.
 - h. Supply: Over-the-rim fill spout.
 - i. Drains: Two waste connections.
 - j. Electric Turbine Ejectors: Two; one rail mounted on each side.
 - k. Thermostatic, mixing-valve assembly.
 - l. Unit Electrical Characteristics:
 - 1) Volts: **[120][240][277][480]<Insert number>**.
 - 2) Phase(s): **[One][Three]**.
 - 3) Hertz: **[60]<Insert number>**.
 - 4) Full-Load Amperes: **<Insert value>**.
 - 5) Minimum Circuit Ampacity: **<Insert value>**.
 - 6) Maximum Overcurrent Protection: **<Insert amperage>**.
 - m. Hose and handheld shower.
 - n. Wash-out-hose assembly.
 - o. Stretcher lift.
 - p. Overhead **[electric]** hoist.
 - q. **<Insert option>**.
- F. Hydrotherapy Whirlpools, Medium Hubbard Immersion Tank: .
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arjo Inc.]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arjo Inc.]**
 - b. **<Insert manufacturer's name>**
 3. Description: Stationary, butterfly-shaped tank for full-body massage.
 - a. Tank Dimensions: **[100 by 73 by 24 inches (2540 by 1854 by 610 mm)]<Insert dimensions>**.
 - b. Overall Height: **[34 to 38 inches (864 to 965 mm)]<Insert dimensions>**.

- c. Water Capacity: [377 gal. (1468 L)]<Insert value>.
- d. Material: Stainless steel.
- e. Supports: Legs or base.
- f. Controls.
- g. Thermometer: Control panel or tank rim mounted.
- h. Supply: Over-the-rim fill spout.
- i. Drain: One waste connection.
- j. Electric Turbine Ejector: One; panel mounted.
- k. Thermostatic, mixing-valve assembly.
- l. Unit Electrical Characteristics:
 - 1) Volts: [120][240][277][480]<Insert number>.
 - 2) Phase(s): [One][Three].
 - 3) Hertz: [60]<Insert number>.
 - 4) Full-Load Amperes: <Insert value>.
 - 5) Minimum Circuit Ampacity: <Insert value>.
 - 6) Maximum Overcurrent Protection: <Insert amperage>.
- m. Hose and handheld shower.
- n. Wash-out-hose assembly.
- o. Stretcher lift.
- p. Overhead[electric] hoist.
- q. <Insert option>.

G. Hydrotherapy Whirlpools, Large Hubbard Immersion Tank: .

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Whitehall Manufacturing; a division of Morris Group International]
 - b. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Whitehall Manufacturing; a division of Morris Group International]
 - b. <Insert manufacturer's name>
- 3. Description: Stationary, butterfly-shaped tank for full-body massage.
 - a. Tank Dimensions: [106 by 77 by 22 inches (2692 by 1956 by 560 mm)]<Insert dimensions>.
 - b. Overall Height: [34 inches (864 mm)]<Insert dimension>.
 - c. Water Capacity: [425 gal. (1609 L)]<Insert value>.
 - d. Material: Stainless steel.
 - e. Supports: Legs or base.
 - f. Controls.
 - g. Thermometer: Control panel or tank rim mounted.
 - h. Supply: Over-the-rim fill spout.
 - i. Drain(s): One or two waste connections.
 - j. Electric Turbine Ejectors: Two; one rail mounted on each side.
 - k. Thermostatic mixing-valve assembly.

I. Unit Electrical Characteristics:

- 1) Volts: [120][240][277][480]<Insert number>.
- 2) Phase(s): [One][Three].
- 3) Hertz: [60]<Insert number>.
- 4) Full-Load Amperes: <Insert value>.
- 5) Minimum Circuit Ampacity: <Insert value>.
- 6) Maximum Overcurrent Protection: <Insert amperage>.

- m. Hose and handheld shower.
- n. Wash-out-hose assembly.
- o. Stretcher lift.
- p. Overhead[electric] hoist.
- q. <Insert option>.

H. Hydrotherapy Whirlpools, Full-Body Immersion Tank: .

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arjo Inc.]
 - b. [Whitehall Manufacturing; a division of Morris Group International]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arjo Inc.]
 - b. [Whitehall Manufacturing; a division of Morris Group International]
 - c. <Insert manufacturer's name>
3. Description: Stationary rectangular tank for full-body massage.
 - a. Tank Dimensions: [90 by 32 by 19 inches (2286 by 813 by 483 mm)][95 by 41 by 22 inches (2413 by 1041 by 560 mm)]<Insert dimensions>.
 - b. Overall Height: 32 or 34 inches (813 or 860 mm).
 - c. Water Capacity: [195 gal. (738 L)][260 gal. (984 L)]<Insert value>.
 - d. Material: Stainless steel.
 - e. Supports: Legs or base.
 - f. Controls.
 - g. Thermometer: Control panel or tank rim mounted.
 - h. Supply: Over-the-rim fill spout.
 - i. Drain(s): One or two waste connections.
 - j. Electric Turbine Ejector: One, tank mounted [at end][on rail][on side].
 - k. Thermostatic mixing-valve assembly.
 - l. Unit Electrical Characteristics:
 - 1) Volts: [120][240][277][480]<Insert number>.
 - 2) Phase(s): [One][Three].
 - 3) Hertz: [60]<Insert number>.
 - 4) Full-Load Amperes: <Insert value>.
 - 5) Minimum Circuit Ampacity: <Insert value>.
 - 6) Maximum Overcurrent Protection: <Insert amperage>.

- m. Hose and handheld shower.
- n. Wash-out-hose assembly.
- o. Stretcher lift.
- p. Overhead[**electric**] hoist.
- q. **<Insert option>**.

2.18 OUTLET BOXES**A. Outlet Boxes, for Dialysis Equipment: .**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[Metcraft Industries, Inc.]**
 - c. **[Whitehall Manufacturing; a division of Morris Group International]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[Metcraft Industries, Inc.]**
 - c. **[Whitehall Manufacturing; a division of Morris Group International]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Description: Recessed-mounted outlet box with water-supply and drain connections.
 - a. Box and Faceplate: Stainless steel.
 - b. Supply Fitting(s): **[One][Two] NPS 1/2 (DN 15)** PVC ball valve(s) and adapter with male hose-thread outlet.
 - c. Drain: **NPS 2 (DN 50)** standpipe, P-trap, and direct waste connection to drainage piping.
4. Reinforcement: Fire-retardant-treated wood blocking between studs. Comply with fire-retardant-treated wood requirements specified in Section 061000 "Rough Carpentry."

2.19 MORGUE EQUIPMENT**A. Autopsy Table: .**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[CSI Industries Inc.]**
 - b. **[LEEC]**
 - c. **[Mopec]**

- d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CSI Industries Inc.]
 - b. [LEEC]
 - c. [Mopec]
 - d. <Insert manufacturer's name>
 3. Description: Pedestal, stainless steel table with sink; designed for downdraft ventilation.
 - a. Material: Stainless steel.
 - b. Nominal Size: [88 by 30 inches (2250 by 762 mm)]<Insert dimensions> with deck faucet holes.
 - c. Faucet: Manufacturer's standard, deck mounted with wrist- or elbow-blade handles.
 - d. Aspirator: Deck mounted.
 - e. Removable body supports.
 - f. Rinse Assembly: Deck-mounted faucet with hose.
 - g. Disposer: [Not required][Required, in accordance with UL 430].
 - h. Receptacle: Duplex, hospital grade with ground-fault interruption.
 - i. Supplies: With atmospheric vacuum breakers, in accordance with ASSE 1001, and stops.
 - j. Drain: [Grid]<Insert type> with NPS 1-1/2 (DN 40) tailpiece.
 - k. Waste piping.
 - l. Unit Electrical Characteristics:
 - 1) Volts: [120][240][277][480]<Insert number>.
 - 2) Phase(s): [One][Three].
 - 3) Hertz: [60]<Insert number>.
 - 4) Full-Load Amperes: <Insert value>.
 - 5) Minimum Circuit Ampacity: <Insert value>.
 - 6) Maximum Overcurrent Protection: <Insert amperage>.
- B. Dissecting Sink: .
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CSI Industries Inc.]
 - b. [LEEC]
 - c. [Mopec]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CSI Industries Inc.]
 - b. [LEEC]
 - c. [Mopec]
 - d. <Insert manufacturer's name>
 3. Description: Wall-mounted sink with backsplash.

- a. Material: Stainless steel.
- b. Nominal Size:
 - 1) **[84 by 28 inches (2130 by 710 mm)]<Insert dimensions>** with back faucet holes.
 - 2) Approximately **30 inches (760 mm)** wide.
- c. Equipment drawer.
- d. Faucet: **<Insert faucet designation>**.
- e. Aspirator: Back mounted.
- f. Rinse Assembly: One back-mounted faucet with hose.
- g. Disposer: **[Not required][Required, in accordance with UL 430]**.
- h. Support: ASME A112.6.1M, **[Type I sink carrier][Type III sink carrier]<Insert carrier>**.
- i. Supplies: With atmospheric vacuum breakers, in accordance with ASSE 1001, and stops.
- j. Drain: **[Grid]<Insert type>** with **NPS 1-1/2 (DN 40)** tailpiece.
- k. Waste Piping: Comply with requirements in "Waste Fittings" Article.
- l. Back-mounted, handheld eye wash.
- m. Unit Electrical Characteristics:
 - 1) Volts: **[120][240][277][480]<Insert number>**.
 - 2) Phase(s): **[One][Three]**.
 - 3) Hertz: **[60]<Insert number>**.
 - 4) Full-Load Amperes: **<Insert value>**.
 - 5) Minimum Circuit Ampacity: **<Insert value>**.
 - 6) Maximum Overcurrent Protection: **<Insert amperage>**.

2.20 SUPPORTS

A. Water-Closet Carrier: **<Insert carrier type>**.

- 1. Description: Waste-fitting assembly as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture.
Include additional extension coupling, faceplate, and feet for installation in wide pipe space.]
- 2. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Jay R. Smith Mfg Co; a division of Morris Group International]**
 - b. **[Josam Company]**
 - c. **[MIFAB, Inc]**
 - d. **[Wade; a subsidiary of McWane Inc.]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**
- 3. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Jay R. Smith Mfg Co; a division of Morris Group International]**
 - b. **[Josam Company]**
 - c. **[MIFAB, Inc]**
 - d. **[Wade; a subsidiary of McWane Inc.]**

- e. [WATTS; A Watts Water Technologies Company]
- f. [Zurn Industries, LLC]
- g. <Insert manufacturer's name>

B. Type I Sink Carrier: <Insert sink designation>.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>

C. Type II Sink Carrier: <Insert sink designation>.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]

g. <Insert manufacturer's name>

D. Type III Sink Carrier: <Insert sink designation>.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
3. Support Brackets: [~~White-enameled~~]steel.

E. Type IV Sink Carrier: <Insert sink designation>.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]

- f. [Zurn Industries, LLC]
- g. <Insert manufacturer's name>

2.21 SUPPLY FITTINGS

- A. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless steel wall flange.
- B. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- C. Operation: [Loose key][Wheel handle]<Insert type>.
- D. Risers: **NPS 1/2 (DN 15)** [chrome-plated, rigid-copper pipe and brass straight or offset tailpieces][chrome-plated, soft-copper flexible tube][ASME A112.18.6, braided or corrugated stainless steel, flexible hose].

2.22 WASTE FITTINGS

- A. Drain: [Grid]<Insert type> with **NPS 1-1/2 (DN 40)** tailpiece.
- B. Trap:
 - 1. Size: **NPS 1-1/2 (DN 40)**.
 - 2. Material:
 - a. Chrome-plated, [two-piece, cast-brass trap and swivel elbow with 0.032-inch- (0.83-mm-) thick, brass tube to wall][two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch- (0.83-mm-) thick, brass tube to wall][one-piece, cast-brass trap with swivel 0.029-inch- (73-mm-) thick, tubular brass wall bend]<Insert trap type>; and chrome-plated brass or steel wall flange.
 - b. Stainless steel, two-piece trap and swivel elbow with 0.012-inch- (0.30-mm-) thick, stainless steel tube to wall; and stainless steel wall flange.

2.23 GROUT

- A. Characteristics: Nonshrink; recommended for interior and exterior applications.
- B. Design Mix: **5000 psi (34.5 MPa)**, 28-day compressive strength.
- C. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.
- B. Examine walls, floors, cabinets, and counters for suitable conditions where fixtures will be installed.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HEALTHCARE PLUMBING FIXTURES

- A. Install healthcare plumbing fixtures level and plumb in accordance with rough-in drawings.
- B. Install supports, affixed to building substrate, for wall-mounted fixtures.
 - 1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 - 2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 - 3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
- C. Install floor-mounted healthcare water closets on bowl-to-drain, connecting fitting attachments to piping or building substrate.
- D. Install counter-mounted fixtures in, and attached to, casework.
- E. Install water-supply piping with stop on each supply to each fixture to be connected to water-distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
 - 1. Exception for use of ball or gate valve if supply stops are not specified with fixture. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
- F. Install flushometer valves on healthcare water closets.
- G. Install flushometer valves for accessible healthcare water closets, with lever handle mounted on wide side of compartment.
- H. Install toilet seats on healthcare water closets.
- I. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts, if faucets are not available with required rates and patterns. Include adapters if required.
- J. Install laminar-flow, faucet-spout fittings in faucet spouts where laminar-flow fittings are specified.
- K. Install shower flow-control fittings with specified maximum flow rates in shower arms.
- L. Install traps on fixture outlets.
 - 1. Exception for omission of trap on fixtures with integral traps.
- M. Set healthcare showers in leveling bed of cement grout.
- N. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."
- O. Seal joints between healthcare plumbing fixtures, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
- P. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-

pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."

3.3 PIPING CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with requirements for water piping specified in Section 221116 "Domestic Water Piping."
- C. Comply with requirements for soil and waste drainage piping[**and vent piping**] specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Comply with requirements for atmospheric vent piping specified in Section 221316 "Sanitary Waste and Vent Piping."
- E. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert dimension> high.

3.5 ADJUSTING

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning healthcare plumbing fixtures, fittings, and controls.
- B. Adjust water pressure at [faucets][and][flushometer valves] to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.6 CLEANING AND PROTECTION

- A. After installing healthcare plumbing fixtures, inspect and repair damaged finishes.
- B. Clean healthcare plumbing fixtures, faucets, and other fittings with manufacturers' recommended

22 - Plumbing



cleaning methods and materials.

- C. Provide protective covering for installed fixtures and fittings.
- D. Do not allow use of healthcare plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 43 00 00



Task	Specification	Specification Description
22 43 13 00	22 45 00 00	Emergency Plumbing Fixtures
22 43 16 00	22 45 00 00	Emergency Plumbing Fixtures
22 43 39 00	22 43 00 00	Healthcare Plumbing Fixtures
22 43 39 00	22 45 00 00	Emergency Plumbing Fixtures



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 45 00 00 - EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Emergency showers.
2. Emergency eyewashes.
3. Emergency eye/face washes.
4. Emergency combination showers with eyewashes.
5. Emergency combination showers with eye/face washes.
6. Emergency recessed safety stations.
7. Supplemental equipment.
8. Water-tempering equipment.

1.2 DEFINITIONS

- A. Barrier-Free Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.
- B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.
- C. Portable, Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid supply.
- D. Tepid: Between **60 and 100 deg F (16 and 38 deg C)**.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include flow rates and capacities, furnished specialties, and accessories.

B. Shop Drawings:

1. Plans, elevations, sections, and **[mounting][attachment]** details.
2. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Emergency fixture third-party certification documentation.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For emergency plumbing fixtures.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Flushing-Fluid Solution: Separate lot and equal to at least **[200]<Insert number>** percent of amount of solution installed for each self-contained unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Plumbing fixtures intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act, with requirements of authorities having jurisdiction, and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
- B. Comply with requirements in ICC A117.1 for installation of barrier-free emergency fixtures.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 EMERGENCY SHOWERS

- A. Emergency Shower - Freestanding, Plumbed :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Guardian Equipment Co]**
 - d. **[Haws Corporation]**
 - e. **[Stingray Systems LLC]**
 - f. **[WaterSaver Faucet Co]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**

- c. **[Guardian Equipment Co]**
 - d. **[Haws Corporation]**
 - e. **[Stingray Systems LLC]**
 - f. **[WaterSaver Faucet Co]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain emergency showers, freestanding, plumbed, from single manufacturer.
 4. Standards:
 - a. ANSI/ISEA Z358.1
 - b. ASME A112.18.1/CSA B125.1.
 5. Capacity: Not less than **20 gpm (76 L/min.)** for at least 15 minutes.
 6. Supply Connection Size: **[NPS 1-1/4 (DN 32)]<Insert size>**.
 7. Integral Supply Pipe Material: **[Galvanized steel][Stainless steel]<Insert material>**.
 8. Control Valve:
 - a. Type: Stay-open type with flow regulator.
 - b. Actuator: Pull rod[, **60-inch (1524-mm)**].
 9. Shower Head: **[3-inch- (76-mm-)][8-inch- (200-mm-)]** minimum-diameter, **[stainless steel][plastic]<Insert material>**.
 10. Mounting: Pedestal[, **barrier-free**].
 11. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Modesty curtain.
 - e. Magnetically actuated proximity switch.
 - f. **<Insert size>** stainless steel ball valve.
 - g. **<Insert accessory>**.

B. Emergency Shower - Off Floor, Plumbed :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Sellstrom Manufacturing Company]**
 - g. **[Speakman Company]**
 - h. **[Stingray Systems LLC]**
 - i. **[WaterSaver Faucet Co]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Acorn Safety; a Division of Morris Group International]
 - b. [Bradley Corporation]
 - c. [Encon Safety Products]
 - d. [Guardian Equipment Co]
 - e. [Haws Corporation]
 - f. [Sellstrom Manufacturing Company]
 - g. [Speakman Company]
 - h. [Stingray Systems LLC]
 - i. [WaterSaver Faucet Co]
 - j. <Insert manufacturer's name>
3. Source Limitations: Obtain emergency showers, off floor, plumbed, from single manufacturer.
 4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 5. Capacity: Not less than **20 gpm (76 L/min.)** for at least 15 minutes.
 6. Supply Connection Size: **NPS 1 (DN 25)**.
 7. Integral Supply Pipe Material: **[Galvanized steel][Chrome-plated brass][Stainless steel]**.
 8. Control Valve:
 - a. Type: Stay-open type with flow regulator.
 - b. Actuator: Pull rod[, **60-inch (1524-mm)**].
 9. Shower Head: **[3-inch- (76-mm-)][8-inch- (200-mm-)]** minimum-diameter, **[stainless steel][plastic]<Insert material>**.
 10. Mounting: **[Horizontal from wall][Vertical from ceiling][, barrier-free]** and supported from structure.
 11. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Modesty curtain.
 - e. Magnetically actuated proximity switch.
 - f. <Insert size> stainless steel ball valve.
 - g. <Insert accessory>.

C. Emergency Shower - Wall Mounted, Fully Recessed, Plumbed :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Acorn Safety; a Division of Morris Group International]
 - b. [Bradley Corporation]
 - c. [Guardian Equipment Co]
 - d. [Haws Corporation]
 - e. [Speakman Company]
 - f. [WaterSaver Faucet Co]
 - g. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Guardian Equipment Co]**
 - d. **[Haws Corporation]**
 - e. **[Speakman Company]**
 - f. **[WaterSaver Faucet Co]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain emergency showers, wall mounted, fully recessed, plumbed, from single manufacturer.
4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
5. Capacity: Not less than **20 gpm (76 L/min.)** for at least 15 minutes.
6. Supply Connection Size: **NPS 1 (DN 25)**.
7. Integral Supply Pipe Material: **[Chrome-plated brass][Stainless steel]<Insert material>**.
8. Control Valve: Stay-open type with flow regulator.
9. Enclosure: Wall-mounted, fully recessed, stainless steel enclosure with vandal-resistant access panel.
10. Shower Head: **[3-inch- (76-mm-)][8-inch- (200-mm-)]** minimum-diameter, stainless steel **<Insert material>**.
11. Mounting: **[Horizontal from wall][Vertical from ceiling][, barrier-free]** and supported from structure.
12. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Modesty curtain.
 - e. Magnetically actuated proximity switch.
 - f. **<Insert size>** stainless steel ball valve.
 - g. **<Insert accessory>**.

D. Emergency Shower - Freeze Resistant, Plumbed :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Guardian Equipment Co]**
 - c. **[Haws Corporation]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Acorn Safety; a Division of Morris Group International]
 - b. [Guardian Equipment Co]
 - c. [Haws Corporation]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain emergency showers, freeze resistant, plumbed, from single manufacturer.
4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
5. Capacity: Not less than **20 gpm (76 L/min.)** for at least 15 minutes.
6. Supply Connection Size: **NPS 1 (DN 25)**.
7. Integral Supply Pipe Material: Galvanized steel.
8. Control Valve:
 - a. Type: Stay-open type with flow regulator.
 - b. Actuator: Wall-mounted push handle.
9. Shower Head: **[3-inch- (76-mm-)][8-inch- (200-mm-)]** minimum-diameter, **[stainless steel][plastic]<Insert material>**.
10. Mounting: Horizontal from wall[, **barrier-free**]. Concealed piping within heated space.
11. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Modesty curtain.
 - e. Magnetically actuated proximity switch.
 - f. <Insert size> stainless steel ball valve.
 - g. <Insert accessory>.

2.3 EMERGENCY EYEWASHES

A. Emergency Eyewash - Standard, Freestanding, Plumbed :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Bradley Corporation]
 - b. [Guardian Equipment Co]
 - c. [Speakman Company]
 - d. [Stingray Systems LLC]
 - e. [WaterSaver Faucet Co]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Bradley Corporation]
 - b. [Guardian Equipment Co]
 - c. [Speakman Company]
 - d. [Stingray Systems LLC]
 - e. [WaterSaver Faucet Co]
 - f. <Insert manufacturer's name>
 3. Source Limitations: Obtain emergency eyewashes, standard, freestanding, plumbed, from single manufacturer.
 4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 5. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
 6. Supply Connection Size: **NPS 1/2 (DN 15)**.
 7. Integral Supply Pipe Material: **[Galvanized steel][Stainless steel]<Insert material>**.
 8. Control Valve:
 - a. Type: Stay-open type valve with flow regulator.
 - b. Actuator: **[Paddle][Treadle]<Insert actuator>**.
 9. Spray-Head Assembly: Two receptor-mounted spray heads.
 10. Receptor: **[Stainless steel][Plastic]** bowl.
 11. Drain Piping:
 - a. Size: **NPS 1-1/4 (DN 32)** minimum.
 - b. Finish: Chrome-plated brass.
 - c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange.
 12. Mounting: Pedestal.
 13. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Dust covers.
 - e. Magnetically actuated proximity switch.
 - f. Scald protection valve.
 - g. **<Insert size>** stainless steel ball valve.
 - h. **<Insert accessory>**.
- B. Emergency Eyewash - Barrier-Free, Freestanding, Plumbed :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Bradley Corporation]
 - b. [Stingray Systems LLC]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Bradley Corporation]**
 - b. **[Stingray Systems LLC]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain emergency eyewashes, barrier free, freestanding, plumbed, from single manufacturer.
 4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 5. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
 6. Supply Connection Size: **NPS 1/2 (DN 15)**.
 7. Integral Supply Pipe Material: **[Stainless steel]<Insert material>**.
 8. Control Valve:
 - a. Type: Stay-open type with flow regulator.
 - b. Actuator: **[Paddle]<Insert actuator>**.
 9. Spray-Head Assembly: Two receptor-mounted spray heads.
 10. Receptor: **[Stainless steel][Plastic]** bowl.
 11. Drain Piping:
 - a. Size: **NPS 1-1/4 (DN 32)** minimum.
 - b. Finish: Chrome-plated brass.
 - c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange.
 12. Mounting: Offset pedestal.
 13. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Dust covers.
 - e. Magnetically actuated proximity switch.
 - f. Scald protection valve.
 - g. **<Insert size>** stainless steel ball valve.
 - h. **<Insert accessory>**.
- C. Emergency Eyewash - Standard, Wall Mounted, Plumbed :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bradley Corporation]**
 - b. **[Speakman Company]**
 - c. **[Stingray Systems LLC]**
 - d. **[WaterSaver Faucet Co]**

- e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Bradley Corporation]
 - b. [Speakman Company]
 - c. [Stingray Systems LLC]
 - d. [WaterSaver Faucet Co]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain emergency eyewashes, standard, wall mounted, plumbed, from single manufacturer.
4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
5. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
6. Supply Connection Size: **NPS 1/2 (DN 15)**.
7. Integral Supply Pipe Material: [**Chrome-plated brass**]<Insert material>.
8. Control Valve:
 - a. Type: Stay-open with flow regulator.
 - b. Actuator: [**Paddle**]<Insert actuator>.
9. Spray-Head Assembly: Two receptor-mounted spray heads.
10. Receptor: [**Stainless steel**][**Plastic**]<Insert material> bowl.
11. Drain Piping:
 - a. Size: **NPS 1-1/4 (DN 32)** minimum.
 - b. Finish: Chrome-plated brass.
 - c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange.
12. Mounting: Wall bracket.
13. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Dust covers.
 - e. Magnetically actuated proximity switch.
 - f. Scald protection valve.
 - g. <Insert size> stainless steel ball valve.
 - h. <Insert accessory>.
- D. Emergency Eyewash - Barrier Free, Wall Mounted, Plumbed :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. **[Bradley Corporation]**
 - b. **[Speakman Company]**
 - c. **[Stingray Systems LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bradley Corporation]**
 - b. **[Speakman Company]**
 - c. **[Stingray Systems LLC]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain emergency eyewashes, barrier free, wall mounted, plumbed, from single manufacturer.
4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
5. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
6. Supply Connection: **NPS 1/2 (DN 15)**.
7. Integral Supply Pipe Material: **[Chrome-plated brass]<Insert material>**.
8. Control Valve:
 - a. Type: Stay-open with flow regulator.
 - b. Actuator: **[Paddle]<Insert actuator>**.
9. Spray-Head Assembly: Two receptor-mounted spray heads.
10. Receptor: **[Stainless steel][Plastic]<Insert material>** bowl.
11. Drain Piping:
 - a. Size: **NPS 1-1/4 (DN 32)** minimum.
 - b. Finish: Chrome-plated brass.
 - c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange.
12. Mounting: Wall bracket.
13. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Dust covers.
 - e. Magnetically actuated proximity switch.
 - f. Scald protection valve.
 - g. **<Insert size>** stainless steel ball valve.
 - h. **<Insert accessory>**.

E. Emergency Eyewash - Deck or Wall Mounted, Swivel Type, Plumbed :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Bradley Corporation]
 - b. [Guardian Equipment Co]
 - c. [Speakman Company]
 - d. [Stingray Systems LLC]
 - e. [WaterSaver Faucet Co]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Bradley Corporation]
 - b. [Guardian Equipment Co]
 - c. [Speakman Company]
 - d. [Stingray Systems LLC]
 - e. [WaterSaver Faucet Co]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain emergency eyewashes, [deck][wall] mounted, swivel type, plumbed, from single manufacturer.
4. Standards:
- a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
5. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
6. Supply Connection Size: **NPS 1/2 (DN 15)**.
7. Integral Supply Pipe Material: [Chrome-plated brass][Stainless steel].
8. Control Valve:
- a. Type: Stay-open type with flow regulator.
 - b. Actuator: [Rotation of spray-head assembly][Paddle]<Insert actuator>.
9. Spray-Head Assembly: Two spray heads with offset piping.
10. Mounting: [Deck mounted next to sink][Deck mounted on sink][Wall mounted]<Insert mounting>.

F. Emergency Eyewash - Portable, Self-Contained :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Bradley Corporation]
 - b. [Encon Safety Products]
 - c. [Guardian Equipment Co]
 - d. [Haws Corporation]
 - e. [Speakman Company]
 - f. [WaterSaver Faucet Co]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Bradley Corporation]**
 - b. **[Encon Safety Products]**
 - c. **[Guardian Equipment Co]**
 - d. **[Haws Corporation]**
 - e. **[Speakman Company]**
 - f. **[WaterSaver Faucet Co]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain emergency eyewashes, portable, self-contained, from single manufacturer.
 4. Standard: ANSI/ISEA Z358.1.
 5. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
 6. Pressure Tank: **[10 gal. (38 L)]<Insert value>**, stainless steel, cylindrical, with pressure gauge, and suitable for on-floor installation.
 7. Flushing Fluid: Medically acceptable solution manufactured and labeled in accordance with applicable regulations.
 8. Spray-Head Assembly: **[Chrome-plated copper alloy][Stainless steel]** piping with flow regulator; control valve; and two spray heads mounted on tank.
 9. Control Valve:
 - a. Type: Stay-open type with flow regulator.
 - b. Actuator: Paddle.
 10. Drench Hose: Handheld spray head with squeeze-handle actuation and hose attached to tank.

G. Emergency Eyewashes - Standard, Self-Contained :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Honeywell Industrial Safety; Honeywell International, Inc.]**
 - g. **[Sellstrom Manufacturing Company]**
 - h. **[Speakman Company]**
 - i. **[WaterSaver Faucet Co]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**

- f. [Honeywell Industrial Safety; Honeywell International, Inc.]
 - g. [Sellstrom Manufacturing Company]
 - h. [Speakman Company]
 - i. [WaterSaver Faucet Co]
 - j. <Insert manufacturer's name>
 - 3. Source Limitations: Obtain emergency eyewashes, standard, self-contained, from single manufacturer.
 - 4. Standard: ANSI/ISEA Z358.1.
 - 5. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
 - 6. Gravity Tank: [**7 gal. (27 L) minimum**]<Insert value>, plastic, and suitable for shelf mounting.
 - 7. Flushing Fluid: Medically acceptable solution manufactured and labeled in accordance with applicable regulations.
 - 8. Actuator: Pull-down front panel or pull strap.
 - 9. Spray Heads: Protected, two mounted on tank.
- H. Emergency Eyewash - Freeze Resistant, Self-Contained :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Bradley Corporation]
 - b. [Encon Safety Products]
 - c. [Guardian Equipment Co]
 - d. [Haws Corporation]
 - e. [Speakman Company]
 - f. [WaterSaver Faucet Co]
 - g. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert **manufacturer's name; product name or designation**> or comparable product by one of the following:
 - a. [Bradley Corporation]
 - b. [Encon Safety Products]
 - c. [Guardian Equipment Co]
 - d. [Haws Corporation]
 - e. [Speakman Company]
 - f. [WaterSaver Faucet Co]
 - g. <Insert manufacturer's name>
 - 3. Source Limitations: Obtain emergency eyewashes, freeze resistant, self-contained, from single manufacturer.
 - 4. Standard: ANSI/ISEA Z358.1.
 - 5. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
 - 6. Gravity Tank: [**7 gal. (27 L) minimum**][**14 gal. (53 L) minimum**][**20 gal. (76 L) minimum**]<Insert value>, plastic, and suitable for shelf mounting.
 - 7. Flushing Fluid: Medically acceptable solution manufactured and labeled in accordance with applicable regulations.
 - 8. Actuator: Pull-down front panel or pull strap.
 - 9. Spray Heads: Protected, two mounted on tank.
 - 10. Heating System: Electric, 120 V ac; insulation enclosed in a protective jacket.

2.4 EMERGENCY EYE/FACE WASHES**A. Emergency Eye/Face Wash - Standard, Freestanding, Plumbed :**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Speakman Company]**
 - g. **[Stingray Systems LLC]**
 - h. **[WaterSaver Faucet Co]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Speakman Company]**
 - g. **[Stingray Systems LLC]**
 - h. **[WaterSaver Faucet Co]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Obtain emergency eye/face washes, standard, freestanding, plumbed, from single manufacturer.
4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
5. Capacity: Not less than **3.0 gpm (11.4 L/min.)** for at least 15 minutes.
6. Supply Connection Size: **NPS 1/2 (DN 15)**.
7. Integral Supply Pipe Material: **[Galvanized steel][Stainless steel][PVC]**.
8. Control Valve:
 - a. Type: Stay-open type with flow regulator.
 - b. Actuator: **[Paddle][Treadle]<Insert actuator>**.
9. Spray-Head Assembly: Two or four receptor-mounted spray heads.
10. Receptor: **[Stainless steel][Plastic]** bowl.
11. Drain Piping:
 - a. Size: **NPS 1-1/4 (DN 32)** minimum.
 - b. Finish: Chrome-plated brass.

- c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange.
- 12. Mounting: Pedestal.
- 13. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Dust covers.
 - e. Magnetically actuated proximity switch.
 - f. Scald protection valve.
 - g. **<Insert size>** stainless steel ball valve.
 - h. **<Insert accessory>**.
- B. Emergency Eye/Face Wash - Barrier Free, Freestanding, Plumbed :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Guardian Equipment Co]**
 - d. **[Stingray Systems LLC]**
 - e. **[WaterSaver Faucet Co]**
 - f. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Guardian Equipment Co]**
 - d. **[Stingray Systems LLC]**
 - e. **[WaterSaver Faucet Co]**
 - f. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain emergency eye/face washes, barrier free, freestanding, plumbed, from single manufacturer.
 - 4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 - 5. Capacity: Not less than **3.0 gpm (11.4 L/min.)** for at least 15 minutes.
 - 6. Supply Connection Size: **NPS 1/2 (DN 15)**.
 - 7. Integral Supply Pipe Material: **[Galvanized steel][Stainless steel]**.
 - 8. Control Valve:
 - a. Type: Stay-open type with flow regulator.
 - b. Actuator: **[Paddle]<Insert actuator>**.

9. Spray-Head Assembly: Two or four receptor-mounted spray heads.
10. Receptor: **[Stainless steel][Plastic]** bowl.
11. Drain Piping:
 - a. Size: **NPS 1-1/4 (DN 32)** minimum.
 - b. Finish: Chrome-plated brass.
 - c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2.
12. Mounting: Offset pedestal.
13. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Dust covers.
 - e. Magnetically actuated proximity switch.
 - f. Scald protection valve.
 - g. **<Insert size>** stainless steel ball valve.
 - h. **<Insert accessory>**.

C. Emergency Eye/Face Wash - Standard, Wall Mounted, Plumbed :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Speakman Company]**
 - g. **[Stingray Systems LLC]**
 - h. **[WaterSaver Faucet Co]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Speakman Company]**
 - g. **[Stingray Systems LLC]**
 - h. **[WaterSaver Faucet Co]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Obtain emergency eye/face washes, standard, wall mounted, plumbed, from single manufacturer.

4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
5. Capacity: Not less than **3.0 gpm (11.4 L/min.)** for at least 15 minutes.
6. Supply Connection Size: **NPS 1/2 (DN 15)**.
7. Integral Supply Pipe Material: [**Chrome-plated brass**][**Stainless steel**][**PVC**]<Insert material>.
8. Control Valve:
 - a. Type: Stay-open type with flow regulator.
 - b. Actuator: [**Paddle**]<Insert actuator>.
9. Spray-Head Assembly: Two or four receptor-mounted spray heads.
10. Receptor: [**Stainless steel**][**Plastic**]<Insert material> bowl.
11. Drain Piping:
 - a. Size: **NPS 1-1/4 (DN 32)** minimum.
 - b. Finish: Chrome-plated brass.
 - c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange.
12. Mounting: Wall bracket.
13. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Dust covers.
 - e. Magnetically actuated proximity switch.
 - f. Scald protection valve.
 - g. <Insert size> stainless steel ball valve.
 - h. <Insert accessory>.

D. Emergency Eye/Face Wash - Barrier Free, Wall Mounted, Plumbed :

1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. [**Acorn Safety; a Division of Morris Group International**]
 - b. [**Bradley Corporation**]
 - c. [**Guardian Equipment Co**]
 - d. [**Haws Corporation**]
 - e. [**Speakman Company**]
 - f. [**Stingray Systems LLC**]
 - g. [**WaterSaver Faucet Co**]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert **manufacturer's name; product name or designation**> or comparable product by one of the following:
 - a. [**Acorn Safety; a Division of Morris Group International**]

- b. [Bradley Corporation]
 - c. [Guardian Equipment Co]
 - d. [Haws Corporation]
 - e. [Speakman Company]
 - f. [Stingray Systems LLC]
 - g. [WaterSaver Faucet Co]
 - h. <Insert manufacturer's name>
- 3. Source Limitations: Obtain emergency eye/face washes, accessible, wall mounted, plumbed, from single manufacturer.
- 4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
- 5. Capacity: Not less than **3.0 gpm (11.4 L/min.)** for at least 15 minutes.
- 6. Supply Connection Size: **NPS 1/2 (DN 15)**.
- 7. Integral Supply Pipe Material: [**Chrome-plated brass**][**Stainless steel**].
- 8. Control Valve:
 - a. Type: Stay-open with flow regulator.
 - b. Actuator: [**Paddle**]<Insert actuator>.
- 9. Spray-Head Assembly: Two or four receptor-mounted spray heads.
- 10. Receptor: [**Stainless steel**][**Plastic**]<Insert material> bowl.
- 11. Drain Piping:
 - a. Size: **NPS 1-1/4 (DN 32)** minimum.
 - b. Finish: Chrome-plated brass.
 - c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange.
- 12. Mounting: Wall bracket.
- 13. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Dust covers.
 - e. Magnetically actuated proximity switch.
 - f. Scald protection valve.
 - g. <Insert size> stainless steel ball valve.
 - h. <Insert accessory>.

E. Emergency Eye/Face Wash - Deck or Wall Mounted, Swivel Type, Plumbed :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Acorn Safety; a Division of Morris Group International]
 - b. [Bradley Corporation]
 - c. [Guardian Equipment Co]

- d. [Haws Corporation]
 - e. [Stingray Systems LLC]
 - f. [WaterSaver Faucet Co]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Acorn Safety; a Division of Morris Group International]
 - b. [Bradley Corporation]
 - c. [Guardian Equipment Co]
 - d. [Haws Corporation]
 - e. [Stingray Systems LLC]
 - f. [WaterSaver Faucet Co]
 - g. <Insert manufacturer's name>
 3. Source Limitations: Obtain emergency eye/face washes, [deck][wall] mounted, swivel type, plumbed, from single manufacturer.
 4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 5. Capacity: Not less than **3 gpm (11.4 L/min.)** for at least 15 minutes.
 6. Supply Connection Size: **NPS 1/2 (DN 15)**.
 7. Integral Supply Pipe Material: [Chrome-plated brass][Stainless steel].
 8. Control Valve:
 - a. Type: Stay-open with flow regulator.
 - b. Actuator: Movement of spray-head assembly.
 9. Spray-Head Assembly: Two or four spray heads with offset piping.
 10. Mounting: [Deck mounted][Wall mounted]<Insert mounting>.
 - a. Location: [Deck mounted next to sink][Deck mounted on sink][Wall mounted behind sink]<Insert mounting>
- F. Emergency Eye/Face Wash - Deck Mounted, Plumbed :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Acorn Safety; a Division of Morris Group International]
 - b. [Guardian Equipment Co]
 - c. [WaterSaver Faucet Co]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Acorn Safety; a Division of Morris Group International]
 - b. [Guardian Equipment Co]

- c. **[WaterSaver Faucet Co]**
- d. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain emergency eye/face washes, deck mounted, plumbed, from single manufacturer.
- 4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
- 5. Capacity: Not less than **3 gpm (11.4 L/min.)** for at least 15 minutes.
- 6. Supply Connection Size: **NPS 1/2 (DN 15)**.
- 7. Integral Supply Pipe Material: Chrome-plated brass.
- 8. Control Valve:
 - a. Type: Stay-open type valve with flow regulator.
 - b. Actuator: **[Paddle][Push down]<Insert actuator>**.
- 9. Spray-Head Assembly: Two or four spray heads.
- 10. Receptor: Stainless steel **<Insert material>** bowl.
- 11. Drain Piping:
 - a. Size: **NPS 1-1/4 (DN 32)** minimum.
 - b. Fittings: Receptor drain, P-trap, waste to wall, and wall flange.
- 12. Mounting: Deck.
- 13. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Dust covers.
 - e. Magnetically actuated proximity switch.
 - f. Scald protection valve.
 - g. **<Insert size>** stainless steel ball valve.
 - h. **<Insert accessory>**.

2.5 EMERGENCY COMBINATION SHOWERS WITH EYEWASHES

A. Emergency Combination Shower with Eyewash, Standard, Plumbed :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Speakman Company]**

- g. [Stingray Systems LLC]
 - h. [WaterSaver Faucet Co]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Acorn Safety; a Division of Morris Group International]
 - b. [Bradley Corporation]
 - c. [Encon Safety Products]
 - d. [Guardian Equipment Co]
 - e. [Haws Corporation]
 - f. [Speakman Company]
 - g. [Stingray Systems LLC]
 - h. [WaterSaver Faucet Co]
 - i. <Insert manufacturer's name>
3. Source Limitations: Obtain emergency combination showers with eyewashes, standard, plumbed, from single manufacturer.
4. Standards:
- a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
5. Integral Supply/Drain Pipe:
- a. Material: [Galvanized steel][Chrome-plated brass][Stainless steel][PVC].
 - b. Supply Connection Size: [NPS 1-1/4 (DN 32) minimum][NPS 1-1/2 (DN 40)].
 - c. Drain Connection Size: Outlet at back or side near bottom. NPS 1-1/4 (DN 32) minimum.
6. Shower:
- a. Capacity: Not less than 20 gpm (76 L/min.) for at least 15 minutes.
 - b. Supply Piping: NPS 1 (DN 25).
 - c. Control Valve:
 - 1) Stay-open type with flow regulator.
 - 2) Actuator: [Pull rod][, 60-inch (1524-mm)][Treadle]<Insert actuator>.
 - d. Shower Head: [3-inch- (76-mm-)][8-inch- (200-mm-)] minimum diameter, [stainless steel][plastic].
 - e. Mounting: Pedestal.
7. Eyewash:
- a. Capacity: Not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
 - b. Supply Piping Size: NPS 1/2 (DN 15).
 - c. Control Valve:
 - 1) Stay-open with flow regulator.
 - 2) Actuator: Paddle.
 - d. Spray-Head Assembly: Two receptor-mounted spray heads.
 - e. Receptor: [Stainless steel][Plastic] bowl.

- f. Mounting: Attached to shower pedestal.
- g. Drench-Hose Option: May be provided instead of eyewash unit.
 - 1) Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
 - 2) Drench Hose: Handheld spray head with squeeze-handle actuator and hose.
 - 3) Mounting: Bracket on shower pedestal.

8. Accessories:

- a. Electric alarm with flashing light and horn.
- b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
- c. Flow switch; single pole.
- d. Modesty curtain.
- e. Magnetically actuated proximity switch.
- f. **<Insert size>** stainless steel ball valve.
- g. **<Insert accessory>**.

B. Emergency Combination Shower with Eyewash, Barrier Free, Plumbed :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Stingray Systems LLC]**
 - g. **[WaterSaver Faucet Co]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Stingray Systems LLC]**
 - g. **[WaterSaver Faucet Co]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain emergency combination showers with eyewashes, barrier free, plumbed, from single manufacturer.
4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.

5. Integral Supply/Drain Pipe:
 - a. Material: **[Galvanized steel][Stainless steel]**.
 - b. Supply Connection Size: **[NPS 1-1/4 (DN 32) minimum][NPS 1-1/2 (DN 40)]**.
 - c. Drain Connection Size: Outlet at back or side near bottom. **NPS 1-1/4 (DN 32)** minimum.
6. Shower:
 - a. Capacity: Not less than **20 gpm (76 L/min.)** for at least 15 minutes.
 - b. Supply Piping: **NPS 1 (DN 25)** with flow regulator and stay-open control valve.
 - c. Control Valve:
 - 1) Type: Stay-open type with flow regulator.
 - 2) Actuator: **[Pull rod][, 60-inch (1524-mm)]<Insert actuator>**.
 - d. Shower Head: **[3-inch- (76-mm-)][8-inch- (200-mm-)]** minimum diameter, **[stainless steel][plastic]**.
 - e. Mounting: Pedestal.
7. Eyewash:
 - a. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
 - b. Supply Piping: **NPS 1/2 (DN 15)** with flow regulator and stay-open control valve.
 - c. Control Valve:
 - 1) Type: Stay-open type with flow regulator.
 - 2) Actuator: Paddle.
 - d. Spray-Head Assembly: Two receptor-mounted spray heads.
 - e. Receptor: **[Stainless steel][Plastic]** bowl.
 - f. Mounting: Attached shower pedestal.
 - g. Drench-Hose Option: May be provided instead of eyewash unit.
 - 1) Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
 - 2) Drench Hose: Handheld spray head with squeeze-handle actuator and hose.
 - 3) Mounting: Bracket on shower pedestal.
8. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Modesty curtain.
 - e. Magnetically actuated proximity switch.
 - f. **<Insert size>** stainless steel ball valve.
 - g. **<Insert accessory>**.

2.6 EMERGENCY COMBINATION SHOWERS WITH EYE/FACE WASHES

A. Emergency Combination Shower with Eye/Face Wash, Standard, Plumbed :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [Acorn Safety; a Division of Morris Group International]
 - b. [Bradley Corporation]
 - c. [Encon Safety Products]
 - d. [Guardian Equipment Co]
 - e. [Haws Corporation]
 - f. [Speakman Company]
 - g. [Stingray Systems LLC]
 - h. [WaterSaver Faucet Co]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Acorn Safety; a Division of Morris Group International]
 - b. [Bradley Corporation]
 - c. [Encon Safety Products]
 - d. [Guardian Equipment Co]
 - e. [Haws Corporation]
 - f. [Speakman Company]
 - g. [Stingray Systems LLC]
 - h. [WaterSaver Faucet Co]
 - i. <Insert manufacturer's name>
3. Source Limitations: Obtain emergency combination showers with eye/face washes, standard, plumbed, from single manufacturer.
4. Standards:
- a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
5. Integral Supply/Drain Pipe:
- a. Material: [Galvanized steel][Chrome-plated brass][Stainless steel][PVC].
 - b. Supply Connection Size: [NPS 1-1/4 (DN 32) minimum][NPS 1-1/2 (DN 40)].
 - c. Drain Connection Size: Outlet at back or side near bottom. NPS 1-1/4 (DN 32) minimum.
6. Shower:
- a. Capacity: Not less than **20 gpm (76 L/min.)** for at least 15 minutes.
 - b. Supply Piping: **NPS 1 (DN 25)** with flow regulator and stay-open control valve.
 - c. Control Valve:
 - 1) Type: Stay-open with flow regulator.
 - 2) Actuator: [Pull rod][, 60-inch (1524-mm)][Treadle]<Insert actuator>.
 - d. Shower Head: [3-inch- (76-mm-)][8-inch- (200-mm-)] minimum diameter, [stainless steel][plastic].
 - e. Mounting: Pedestal.
7. Eye/Face Wash:

- a. Capacity: Not less than **3.0 gpm (11.4 L/min.)** for at least 15 minutes.
- b. Supply Piping: **NPS 1/2 (DN 15)** with flow regulator and stay-open control valve.
- c. Control Valve:
 - 1) Type: Stay-open type with flow regulator.
 - 2) Actuator: Paddle.
- d. Spray-Head Assembly: Two or four receptor-mounted spray heads.
- e. Receptor: **[Stainless steel][Plastic]** bowl.
- f. Mounting: Attached shower pedestal.
- g. Drench-Hose Option: May be provided instead of eye/face wash unit.
 - 1) Capacity: Not less than **3.0 gpm (11.4 L/min.)** for at least 15 minutes.
 - 2) Drench Hose: Handheld spray head with squeeze-handle actuator and hose.
 - 3) Mounting: Bracket on shower pedestal.

8. Accessories:

- a. Electric alarm with flashing light and horn.
- b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
- c. Flow switch; single pole.
- d. Modesty curtain.
- e. Magnetically actuated proximity switch.
- f. **<Insert size>** stainless steel ball valve.
- g. **<Insert accessory>**.

B. Emergency Combination Shower with Eye/Face Wash, Barrier Free, Plumbed :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Stingray Systems LLC]**
 - g. **[WaterSaver Faucet Co]**
 - h. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Stingray Systems LLC]**
 - g. **[WaterSaver Faucet Co]**
 - h. **<Insert manufacturer's name>**

3. Source Limitations: Obtain emergency combination showers with eye/face washes, barrier free, plumbed, from single manufacturer.
4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
5. Integral Supply/Drain Pipe:
 - a. Material: **[Galvanized steel][Stainless steel]**.
 - b. Supply Connection Size: **[NPS 1-1/4 (DN 32) minimum][NPS 1-1/2 (DN 40)]**.
 - c. Drain Connection Size: Outlet at back or side near bottom. **NPS 1-1/4 (DN 32) minimum**.
6. Shower:
 - a. Capacity: Not less than **20 gpm (76 L/min.)** for at least 15 minutes.
 - b. Supply Piping: **NPS 1 (DN 25)** with flow regulator and stay-open control valve.
 - c. Control Valve:
 - 1) Type: Stay-open type with flow regulator.
 - 2) Actuator: **[Pull rod][, 60-inch (1524-mm)]<Insert actuator>**.
 - d. Shower Head: **[3-inch- (76-mm-)][8-inch- (200-mm-)]** minimum diameter, **[stainless steel][plastic]**.
 - e. Mounting: Pedestal.
7. Eye/Face Wash:
 - a. Capacity: Not less than **3.0 gpm (11.4 L/min.)** for at least 15 minutes.
 - b. Supply Piping: **NPS 1/2 (DN 15)** with flow regulator and stay-open control valve.
 - c. Control Valve:
 - 1) Type: Stay-open type with flow regulator.
 - 2) Actuator: Paddle.
 - d. Spray-Head Assembly: Two or four receptor-mounted spray heads.
 - e. Receptor: **[Stainless steel][Plastic]** bowl.
 - f. Mounting: Attached to shower pedestal.
 - g. Drench-Hose Option: May be provided instead of eye/face wash unit.
 - 1) Capacity: Not less than **3.0 gpm (11.4 L/min.)** for at least 15 minutes.
 - 2) Drench Hose: Handheld spray head with squeeze-handle actuator and hose.
 - 3) Mounting: Bracket on shower pedestal.
8. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge. ASSE 1071 compliant.
 - c. Flow switch; single pole.
 - d. Modesty curtain.
 - e. Magnetically actuated proximity switch.
 - f. **<Insert size>** stainless steel ball valve.
 - g. **<Insert accessory>**.

- C. Emergency Combination Shower with Eyewash or Eye/Face Wash, Freeze Resistant, Plumbed :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[B-L-S Industries, Inc]**
 - c. **[Bradley Corporation]**
 - d. **[Encon Safety Products]**
 - e. **[Guardian Equipment Co]**
 - f. **[Haws Corporation]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[B-L-S Industries, Inc]**
 - c. **[Bradley Corporation]**
 - d. **[Encon Safety Products]**
 - e. **[Guardian Equipment Co]**
 - f. **[Haws Corporation]**
 - g. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain emergency combination showers with **[eyewashes][eye/face washes]**, freeze resistant, plumbed, from single manufacturer.
 4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 5. Integral Supply Pipe Material: Galvanized steel.
 - a. Supply Connection: **[NPS 1-1/4 (DN 32) minimum][NPS 1-1/2 (DN 40)]**.
 6. Heating System: Electric, **[120][240]** V ac; insulation enclosed in a protective jacket with thermometer.
 - a. Heating Capacity: **[10 deg F (6 deg C)]<Insert temperature>** minimum above ambient temperature.
 - b. Design Ambient Temperature: **<Insert temperature>**.
 7. Shower:
 - a. Shower Capacity: Not less than **20 gpm (76 L/min.)** for at least 15 minutes.
 - b. Supply Piping: **NPS 1 (DN 25)** with flow regulator and stay-open control valve.
 - c. Control Valve:
 - 1) Type: Stay-open type with flow regulator.
 - 2) Actuator: **[Pull rod][, 60-inch (1524-mm)]<Insert actuator>**.
 - d. Shower Head: **[3-inch- (76-mm-)][8-inch- (200-mm-)]** minimum diameter, **[stainless**

- e. **steel**[**plastic**].
Mounting: Pedestal.
8. Eyewash:
- a. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
 - b. Supply Piping: **NPS 1/2 (DN 15)** with flow regulator and stay-open control valve.
 - c. Control Valve:
 - 1) Type: Stay-open with flow regulator.
 - 2) Actuator: [**Paddle**]**<Insert actuator>**.
9. Eye/Face Wash:
- a. Capacity: Not less than **3 gpm (11.4 L/min.)** for at least 15 minutes.
 - b. Control Valve:
 - 1) Type: Stay-open type with flow regulator.
 - 2) Actuator: [**Paddle**]**<Insert actuator>**.
10. Accessories:
- a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge.
 - c. Flow switch; single pole.
 - d. Modesty curtain.
 - e. Magnetically actuated proximity switch.
 - f. **<Insert size>** stainless steel ball valve.
 - g. **<Insert accessory>**.

2.7 EMERGENCY RECESSED SAFETY STATIONS

- A. Emergency Recessed Safety Station - Emergency Eye/Face Wash with Shower, Barrier Free, Plumbed :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Guardian Equipment Co]**
b. **[Haws Corporation]**
c. **[WaterSaver Faucet Co]**
d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Guardian Equipment Co]**
b. **[Haws Corporation]**
c. **[WaterSaver Faucet Co]**
d. **<Insert manufacturer's name>**

3. Source Limitations: Obtain emergency recessed safety stations, emergency eye/face wash with shower, barrier free, plumbed, from single manufacturer.
4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 - d. Barrier-free installation.
5. Cabinet:
 - a. Mounting: Wall-mounted, fully recessed, stainless steel enclosure with vandal-resistant access panel.
 - b. Fire Rated: [**1-hour**][**2-hour**].
 - 1) UL-listed as "Through Penetration Firestop System No. W-L-7167."
 - c. Contents:
 - 1) Supply valves, flow regulator(s), strainers.
 - 2) Eye/face wash with daylight or no drain.
 - 3) Pull-down handle for shower valve activation.
 - 4) Combination cover and internal drain pan. Pull handle on face of unit down from vertical to horizontal position to activate eye/face wash.
 - 5) Internal Drain Connection: Outlet at bottom. **NPS 2 (DN 50)** minimum.
6. Eye/Face Wash:
 - a. Capacity: Not less than **3 gpm (11.4 L/min.)** for at least 15 minutes.
 - b. Supply Piping: **NPS 1/2 (DN 15)** with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Pull handle on face of unit down from vertical to horizontal position.
 - d. Spray-Head Assembly: Two or four receptor-mounted spray heads.
7. Shower:
 - a. Shower Capacity: Not less than **20 gpm (76 L/min.)** for at least 15 minutes.
 - b. Supply Piping: **NPS 1 (DN 25)** with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Pull handle on face of unit from up to down position.
 - d. Shower Head: **8-inch- (200-mm-)** minimum diameter, [**chrome-plated brass**][**stainless steel**][**plastic**].
 - e. Mounting: [**Horizontal from wall, exposed**][**Vertical from ceiling, exposed**][**Vertical from ceiling, recessed**].
8. Accessories:
 - a. Electric alarm with flashing light and horn.
 - b. Thermostatic mixing valve assembly including ball valve shutoffs and outlet temperature gauge.
 - c. Flow switch; single pole.
 - d. Modesty curtain.
 - e. Magnetically actuated proximity switch.
 - f. **<Insert size>** stainless steel ball valve.
 - g. **<Insert accessory>**.

2.8 SUPPLEMENTAL EQUIPMENT**A. Personal Eyewash - Self-Contained :**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Bradley Corporation]**
 - b. **[Encon Safety Products]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bradley Corporation]**
 - b. **[Encon Safety Products]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain self-contained, personal eyewashes from single manufacturer.
4. Standard: ANSI/ISEA Z358.1.
5. Capacity: Not less than **0.4 gpm (1.5 L/min.)**.
6. Pressure Tank: **[5 gal. (19 L)]<Insert value>**, stainless steel, cylindrical, with pressure gauge and base suitable for on-floor installation.
7. Flushing Fluid: Medically acceptable solution manufactured and labeled in accordance with applicable regulations.
8. Spray-Head Assembly: Chrome-plated copper alloy or stainless steel piping with flow regulator; paddle-actuated, stay-open control valve; and two spray heads mounted on tank.

B. Drench Hose - Deck Mounted, Plumbed :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Speakman Company]**
 - f. **[WaterSaver Faucet Co]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Speakman Company]**

- f. **[WaterSaver Faucet Co]**
 - g. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain drench hoses, deck mounted, plumbed, from single manufacturer.
 - 4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - 5. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
 - 6. Supply Fitting: **NPS 1/2 (DN 15)** brass with flow regulator.
 - 7. Drench Hose: Handheld spray head with **[squeeze-handle][push handle ball valve]** actuation and hose.
 - 8. Mounting: In hole on deck.
- C. Drench Hose - Wall Mounted, Plumbed :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Speakman Company]**
 - f. **[WaterSaver Faucet Co]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Bradley Corporation]**
 - c. **[Encon Safety Products]**
 - d. **[Guardian Equipment Co]**
 - e. **[Speakman Company]**
 - f. **[WaterSaver Faucet Co]**
 - g. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain drench hoses, wall mounted, plumbed, from single manufacturer.
 - 4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 - 5. Capacity: Not less than **0.4 gpm (1.5 L/min.)** for at least 15 minutes.
 - 6. Supply Fitting: **NPS 1/2 (DN 15)** brass with flow regulator.
 - 7. Drench Hose: Handheld spray head with **[squeeze-handle][push handle ball valve]** actuation and hose.
 - 8. Mounting: Wall bracket.

2.9 WATER-TEMPERING EQUIPMENT**A. Water-Tempering Equipment - Hot and Cold Water :**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Armstrong International, Inc]**
 - c. **[Bradley Corporation]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Lawler Manufacturing Company, Inc]**
 - g. **[Leonard Valve Company]**
 - h. **[Speakman Company]**
 - i. **[Stingray Systems LLC]**
 - j. **[WaterSaver Faucet Co]**
 - k. **[WATTS; A Watts Water Technologies Company]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Safety; a Division of Morris Group International]**
 - b. **[Armstrong International, Inc]**
 - c. **[Bradley Corporation]**
 - d. **[Guardian Equipment Co]**
 - e. **[Haws Corporation]**
 - f. **[Lawler Manufacturing Company, Inc]**
 - g. **[Leonard Valve Company]**
 - h. **[Speakman Company]**
 - i. **[Stingray Systems LLC]**
 - j. **[WaterSaver Faucet Co]**
 - k. **[WATTS; A Watts Water Technologies Company]**
 - l. **<Insert manufacturer's name>**
3. Source Limitations: Obtain water-tempering equipment, hot and cold water, from single manufacturer.
4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
5. Description: Factory-fabricated equipment with thermostatic mixing valve.
 - a. Thermostatic Mixing Valve: Designed to provide **[85 deg F (29 deg C)]<Insert temperature>** tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus **[5 deg F (3 deg C)]<Insert temperature>** throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, **and corrosion-resistant** enclosure. ASSE 1071 compliant.
 - b. Supply Connections: For hot and cold water.

- c. Cabinet: **[Surface][Recess]** mounted.
- B. Water-Tempering Equipment - Electric, Tankless :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bradley Corporation]**
 - b. **[Chronomite Laboratories, Inc; a division of Morris Group International]**
 - c. **[Encon Safety Products]**
 - d. **[Haws Corporation]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bradley Corporation]**
 - b. **[Chronomite Laboratories, Inc; a division of Morris Group International]**
 - c. **[Encon Safety Products]**
 - d. **[Haws Corporation]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain water-tempering equipment, electric, tankless from single manufacturer.
 4. Standards:
 - a. ANSI/ISEA Z358.1.
 - b. ASME A112.18.1/CSA B125.1.
 5. Description: Factory-fabricated equipment with electric heating.
 - a. Heating System: Electric, designed to provide **[85 deg F (29 deg C)]<Insert temperature>** tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus **[5 deg F (3 deg C)]<Insert temperature>** throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, heating coils, high-temperature-limit device, metal piping, and corrosion-resistant enclosure.
 - 1) Electrical Characteristics: **[208 V ac, single phase][240 V ac, single phase][277 V ac, single phase][208 V ac, 3 phase][240 V ac, 3 phase][480 V ac, 3 phase]**, 60 Hz.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water **[and waste]** piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF EMERGENCY PLUMBING FIXTURES

- A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.
- B. Install fixtures level and plumb.
- C. Fasten fixtures to substrate.
- D. Install shutoff valves in water-supply piping to fixtures, to facilitate maintenance of fixture. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
 - 1. Exceptions:
 - a. Omit shutoff valve on supply to group of plumbing fixtures that includes emergency fixture.
 - b. Omit shutoff valve on supply to emergency fixture if prohibited by authorities having jurisdiction.
- E. Install dielectric fitting in supply piping to emergency fixture if piping and fixture connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."
- F. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."
- G. Install trap and waste piping on drain outlet of emergency fixture receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in **[Section 221316 "Sanitary Waste and Vent Piping."][Section 221316 "Sanitary Waste and Vent Piping" and Section 226600 "Chemical-Waste Systems for Laboratory and Healthcare Facilities."]**
- H. Install indirect waste piping on drain outlet of emergency fixture receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in **[Section 221316 "Sanitary Waste and Vent Piping."][Section 221316 "Sanitary Waste and Vent Piping" and Section 226600 "Chemical-Waste Systems for Laboratory and Healthcare Facilities."]**
- I. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220500 "Common Work Results for Plumbing."
- J. Fill self-contained fixtures with flushing fluid.

3.3 PIPING CONNECTIONS

- A. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."
- B. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."
- C. Connect cold water and electrical power to electric heating water-tempering equipment. Comply with

requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."

- D. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in **[Section 221316 "Sanitary Waste and Vent Piping."][Section 221316 "Sanitary Waste and Vent Piping" and Section 226600 "Chemical-Waste Systems for Laboratory and Healthcare Facilities."]** Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to **[sanitary waste][chemical waste][storm drainage]** piping.
- E. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **[1/2 inch (13 mm)]<Insert dimension>** high.

3.5 IDENTIFICATION

- A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.6 FIELD QUALITY CONTROL

- A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. Emergency plumbing fixtures **[and water-tempering equipment]** will be considered defective if they do not pass tests and inspections.

- C. Prepare test and inspection reports.

3.7 ADJUSTING

- A. Operate and adjust emergency plumbing fixtures and controls. Replace damaged and malfunctioning fixtures and controls.
- B. Adjust or replace fixture flow regulators for proper flow.
- C. Adjust equipment temperature settings.

3.8 CLEANING AND PROTECTION

- A. Clean emergency plumbing fixtures with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed emergency plumbing fixtures and fittings.
- C. Do not allow use of emergency plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 45 00 00



Task	Specification	Specification Description
22 45 13 00	22 45 00 00	Emergency Plumbing Fixtures
22 45 16 00	22 45 00 00	Emergency Plumbing Fixtures
22 45 23 00	22 45 00 00	Emergency Plumbing Fixtures
22 45 26 00	22 45 00 00	Emergency Plumbing Fixtures
22 45 29 00	22 45 00 00	Emergency Plumbing Fixtures
22 45 33 00	22 45 00 00	Emergency Plumbing Fixtures
22 45 36 00	22 45 00 00	Emergency Plumbing Fixtures
22 45 39 00	22 45 00 00	Emergency Plumbing Fixtures



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 46 00 00 - SECURITY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Security combination water closet/lavatory fixtures.
2. Security water closets.
3. Security urinals.
4. Security lavatories.
5. Security drinking fountains.
6. Security showers.
7. Security service sinks.
8. Flushometer valves.
9. Toilet seats.

B. Related Requirements:

1. Section 224200 "Commercial Plumbing Fixtures."
2. Section 224300 "Healthcare Plumbing Fixtures."
3. Section 224500 "Emergency Plumbing Fixtures."
4. Section 224700 "Drinking Fountains and Water Coolers."

1.2 DEFINITIONS

- A. Accessible Service Space:** Service area in secure space behind wall-mounted fixtures.
- B. Back-Access Fixture:** Security plumbing fixture designed to mount on wall sleeve built into wall or on wall, so installation and removal of fixture, piping, and other components are accessible only from service space behind wall.
- C. Front-Access Fixture:** Security plumbing fixture designed to mount on wall with installation and removal from fixture side of wall, and with piping and other components accessible only from access panel in fixture.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for security plumbing fixtures.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. Product Data: For water consumption.
2. WaterSense Fixtures: Provide WaterSense label for toilets, urinals, lavatories, and showerheads.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For security plumbing fixtures and components.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Flushometer-Valve Repair Kits: Equal to **[10]<Insert number>** percent of quantity of each type installed, but no fewer than **[one][six]<Insert number>** of each type.
 - 2. Toilet Seats: Equal to **[five]<Insert number>** percent of quantity of each type installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Faucets and bubblers intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act, with requirements of authorities having jurisdiction, and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 SECURITY COMBINATION WATER CLOSET/LAVATORY FIXTURES

- A. Security Combination Water Closet/Lavatory Fixture - Stainless Steel, Back Access, On or Off Floor, Cabinet :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
- 3. Source Limitations:

- a. Obtain security combination water closet/lavatory fixtures from single manufacturer.
4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.19.5/CSA B45.15.
 - c. ASME A112.18.1/CSA B125.1.
 - d. ASME A112.18.2/CSA B125.2.
 - e. ICC A117.1.
 - f. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction, with fire-resistant sound-deadening material in cabinet interior. Toilet to be able to withstand a **5000 lb (22 kN)** load without deflection and/or damage.
6. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
7. Configuration: **[On][Off]** floor.
8. Cabinet: **[Rectangular apron][Five-sided apron with two angled sides][Four-sided apron with angled left side][Four-sided apron with angled right side]<Insert configuration>**, with backsplash.
 - a. Water-Closet Bowl Location: **[Centered on front][Left of center on front][Right of center on front][On angled left side][On angled right side]<Insert location>** of apron.
 - b. Toilet-Paper Holder: Recessed; stainless steel located **[above water closet and centered in front][in front][right of center in front][left of center in front][in angled right side][in angled left side][in right side][in left side]<Insert location>** of apron.
9. Features: **[ADA compliant][Ligature resistant][ADA compliant and ligature resistant]<Insert feature>**.
10. Accessories:
 - a. Toothbrush Holder: One on **[each][left][right]** side of backsplash.
 - b. Towel Hook: **[One][Two]** on **[each][left][right]** side of fixture.
 - c. Bubbler: On **[backsplash][deck]**.
11. Mounting: Bolts through wall sleeve into accessible service space.
12. Water Closet:
 - a. Bowl:
 - 1) Type: Elongated, with back inlet, integral trap, and **[blowout][siphon-jet]** design with back outlet and integral contoured seat.
 - 2) Seat Surface: Satin polished finish.
 - 3) Punching: Two holes for installation of separate toilet seat.
 - 4) Outlet Connection: **[NPS 3 (DN 80)][NPS 4 (DN 100)]**, horizontal with cleanout and slip joint.
13. Flushometer Valve: **<Insert flushometer valve designation>**.
14. Toilet Seat: **<Insert toilet seat designation>**.
15. Lavatory:
 - a. Location: In top of cabinet.
 - b. Receptor: **[Oval][or][rectangular]** bowl with integral soap depression.
 - c. Hot- and Cold-Water and Bubbler Supply Valves: **[Pneumatic, push-button, single-temperature, metering][Pneumatic, push-button, hot and cold, metering][Electronic, single-temperature, metering][Electronic, hot and cold, metering]** type with individual

- check stops. Non-hold-open valve.
- d. Filler Spout: **[Backsplash][or][deck]** mounted.
- e. Drain: Integral punched grid with **NPS 1-1/4 (DN 32)** minimum waste and trap.

16. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture. Include steel bars or other design to prevent escape if fixture is removed.

B. Security Combination Water Closet/Lavatory Fixture - Stainless Steel, Front Access, On Floor, Cabinet :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations:
 - a. Obtain security combination water closet/lavatory fixtures from single manufacturer.
4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.19.5/CSA B45.15.
 - c. ASME A112.18.1/CSA B125.1.
 - d. ASME A112.18.2/CSA B125.2.
 - e. ICC A117.1.
 - f. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction, with fire-resistant sound-deadening material in cabinet interior. Toilet to be able to withstand a **5000 lb (22 kN)** load without deflection and/or damage.
6. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
7. Cabinet: **[Rectangular apron][Five-sided apron with two angled sides][Four-sided apron with angled left side][Four-sided apron with angled right side]<Insert configuration>**, with backsplash and access panel.
 - a. Water-Closet Bowl Location: **[Centered on front][Left of center on front][Right of center on front][On angled left side][On angled right side]<Insert location>** of apron.
 - b. Toilet-Paper Holder: Recessed; stainless steel located **[above water closet and centered**

in front][in front][right of center in front][left of center in front][in angled right side][in angled left side][in right side][in left side]<Insert location> of apron.

8. Features: **[ADA compliant][Ligature resistant][ADA compliant and ligature resistant]<Insert feature>**.
9. Accessories:
 - a. Toothbrush Holder: One on **[each][left][right]** side of backsplash.
 - b. Towel Hook: **[One][Two]** on **[each][left][right]** side of fixture.
 - c. Bubbler: On **[backsplash][deck]**.
10. Mounting: Bolts through wall sleeve into accessible service space.
11. Water Closet:
 - a. Bowl:
 - 1) Type: Elongated, with back inlet, integral trap, and **[blowout][siphon-jet]** design with back outlet and integral contoured seat.
 - 2) Seat Surface: Satin polished finish.
 - 3) Punching: Two holes for installation of separate toilet seat.
 - 4) Outlet Connection: **[NPS 3 (DN 80)][NPS 4 (DN 100)]**, horizontal with cleanout and slip joint.
12. Flushometer Valve: **<Insert flushometer valve designation>**.
13. Toilet Seat: **<Insert toilet seat designation>**.
14. Lavatory:
 - a. Location: In top of cabinet.
 - b. Receptor: **[Oval][or][rectangular]** bowl with integral soap depression.
 - c. Hot- and Cold-Water and Bubbler Supply Valves: **[Pneumatic, push-button, single-temperature, metering][Pneumatic, push-button, hot and cold, metering][Electronic, single-temperature, metering][Electronic, hot and cold, metering]** type with individual check stops. Non-hold-open valve.
 - d. Filler Spout: **[Backsplash][or][deck]** mounted.
 - e. Drain: Integral punched grid with **NPS 1-1/4 (DN 32)** minimum waste and trap.
15. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture. Include steel bars or other design to prevent escape if fixture is removed.

2.3 SECURITY WATER CLOSETS

A. Security Water Closet - Stainless Steel, Back Access, Off Floor, Back Outlet, Compact :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Acorn Engineering Company; a Division of Morris Group International]**
- b. **[I-Con Systems, Inc.]**
- c. **[Metcraft Industries, Inc.]**
- d. **[Willoughby Industries, Inc.]**
- e. **<Insert manufacturer's name>**

3. Source Limitations:

- a. Obtain security water closets from single manufacturer.

4. Standards:

- a. ASME A112.19.3/CSA B45.4.
- b. ASME A112.19.5/CSA B45.15.
- c. ASME A112.6.1M.
- d. ICC A117.1.
- e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

5. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction. Toilet to be able to withstand a minimum of **1500 lb (7 kN)** load without deflection and/or damage.

6. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.

7. Features: **[ADA compliant]<Insert feature>**.

8. Bowl:

- a. Type: Elongated, with back inlet, integral trap, and blowout design with integral contoured seat.
- b. Length to Wall: Approximately **19 inches (483 mm)**.
- c. Seat Surface: Satin polished finish.
- d. Punching: Two holes for installation of separate toilet seat.

9. Mounting: Bolts through wall sleeve into accessible service space.

10. Mounting Height: **[Standard][Accessible]**.

11. Flushometer Valve: **<Insert flushometer valve designation>**.

12. Toilet Seat: **<Insert toilet seat designation>**.

13. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture. Include steel bars or other design to prevent escape if fixture is removed.

- a. Configuration for Accessible Fixtures: Modify wall sleeve for accessible water-closet mounting height.

B. Security Water Closet - Stainless Steel, Back Access, On or Off Floor, Back or Floor Outlet, Extended Bowl :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Acorn Engineering Company; a Division of Morris Group International]**
- b. **[I-Con Systems, Inc.]**
- c. **[Metcraft Industries, Inc.]**

- d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations:
 - a. Obtain security water closets from single manufacturer.
 4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.19.5/CSA B45.15.
 - c. ASME A112.6.1M.
 - d. ICC A117.1.
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
 5. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction. Toilet to be able to withstand a **5000 lb (22 kN)** load without deflection and/or damage.
 6. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
 7. Configuration: **[On][Off]** floor, **[back][floor]** outlet.
 8. Features: **[ADA compliant]<Insert feature>**.
 9. Bowl:
 - a. Type, for Back-Outlet Water Closet: Elongated, with back inlet, integral trap, and **[blowout][siphon-jet]** design with back outlet and integral contoured seat.
 - b. Type, for Bottom-Outlet Water Closet: Elongated, with back inlet, integral trap, and siphon-jet design with bottom outlet and contoured seat.
 - c. Length to Wall: Minimum of **25 inches (635 mm)**.
 - d. Back-Outlet Connection: **[NPS 3 (DN 80)][NPS 4 (DN 100)]**, horizontal with cleanout and slip joint.
 - e. Bottom-Outlet Connection: **[NPS 3 (DN 80)][NPS 4 (DN 100)]**, vertical.
 - f. Seat Surface: Satin polished finish.
 - g. Punching: Two holes for installation of separate toilet seat.
 10. Mounting: Bolts through wall sleeve into accessible pipe space.
 11. Mounting Height: **[Standard][Accessible]**.
 12. Flushometer Valve: **<Insert flushometer valve designation>**.
 13. Toilet Seat: **<Insert toilet seat designation>**.
 14. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture. Include steel bars or other design to prevent escape if fixture is removed.
 - a. Configuration for Accessible Fixtures: Modify wall sleeve for accessible water-closet mounting height.
- C. Security Water Closet - Stainless Steel, Front Access, On or Off Floor, Back or Floor Outlet, Extended Bowl :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations:
 - a. Obtain security water closets from single manufacturer.
4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.19.5/CSA B45.15.
 - c. ICC A117.1.
 - d. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction. Toilet to be able to withstand a **5000 lb (22 kN)** load without deflection and/or damage.
6. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
7. Configuration: **[On][Off]** floor, **[back][floor]** outlet.
8. Features: **[ADA compliant]<Insert feature>**.
9. Bowl:
 - a. Type, for Back-Outlet Water Closet: Elongated, with back inlet, integral trap, and **[blowout][siphon-jet]** design with back outlet, integral contoured seat, and access panel.
 - b. Type, for Bottom-Outlet Water Closet: Elongated, with back inlet, integral trap, and siphon-jet design with bottom outlet, contoured seat, and access panel.
 - c. Length to Wall: Minimum of **25 inches (635 mm)**.
 - d. Back-Outlet Connection: **[NPS 3 (DN 80)][NPS 4 (DN 100)]**, horizontal with cleanout and slip joint.
 - e. Bottom-Outlet Connection: **[NPS 3 (DN 80)][NPS 4 (DN 100)]**, vertical.
 - f. Seat Surface: Satin polished finish.
 - g. Punching: Two holes for installation of separate toilet seat.
10. Mounting: Bolts from fixture-mounted flanges into wall.
11. Mounting Height: **[Standard][Accessible]**.
12. Flushometer Valve: **<Insert flushometer valve designation>**.
13. Toilet Seat: **<Insert toilet seat designation>**.

14. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture. Include steel bars or other design to prevent escape if fixture is removed.

- a. Configuration for Accessible Fixtures: Modify wall sleeve for accessible water-closet mounting height.

D. Security Water Closet - Vitreous China, Floor Mounted, Back Outlet, Siphon Jet :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Standard]**
 - b. **[Kohler Co]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Standard]**
 - b. **[Kohler Co]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations:
 - a. Obtain security water closets from single manufacturer.
4. Standards:
 - a. ASME A112.19.5/CSA B45.15.
 - b. ICC A117.1.
 - c. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Fixture:
 - a. Bowl: Elongated, vitreous china, with integral trap and integral contoured seat. **[ADA-compliant height.]**
 - b. Spud Location and Size: Back, **NPS 1-1/2 (DN 40)**.
6. Flushometer Valve: **<Insert flushometer valve designation>**.
7. Toilet Seat: **<Insert toilet seat designation>**.
8. Support:
 - a. Description: Waste-fitting assembly as required to match drainage piping material and arrangement with faceplates, couplings, gaskets, and feet; bolts and hardware match fixture. **[Include additional extension coupling, faceplate, and feet for installation in wide pipe space.]**

2.4 SECURITY URINALS

A. Security Urinal - Stainless Steel, Back Access, Back Outlet, Single :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations:
 - a. Obtain security urinals from single manufacturer.
4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.19.5/CSA B45.15.
 - c. ASME A112.6.1M.
 - d. ICC A117.1.
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Fixture:
 - a. Material: Minimum 18-gauge housing with 16-gauge bowl, Type 304 stainless steel, seamless welded construction with fire-resistant sound-deadening material in interior.
 - b. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
 - c. Type and Configuration: **[Blowout][Washout]**, with back inlet.
 - d. Drain: Strainer with **NPS 2 (DN 50)** tailpiece and trap.
 - e. Features: **[ADA compliant]<Insert feature>**.
6. Mounting: Bolts through wall sleeve into accessible service space.
7. Mounting Height: **[Standard][Accessible]**.
8. Flushometer Valve: **<Insert designation>**.
9. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture.

B. Security Urinal - Stainless Steel, Front Access, Back Outlet, Single :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations:
 - a. Obtain security urinals from single manufacturer.
 4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.19.5/CSA B45.15.
 - c. ASME A112.6.1M.
 - d. ICC A117.1.
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
 5. Fixture:
 - a. Material: Minimum 18-gauge housing with 16-gauge bowl, Type 304 stainless steel, seamless welded construction with fire-resistant sound-deadening material in interior.
 - b. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
 - c. Type and Configuration: **[Blowout][Washout]**, with back inlet and access panel.
 - d. Drain: Strainer with **NPS 2 (DN 50)** tailpiece and trap.
 - e. Features: **[ADA compliant]<Insert feature>**.
 6. Mounting: Bolts from fixture-mounted flanges into wall.
 7. Mounting Height: **[Standard][Accessible]**.
 8. Flushometer Valve: **<Insert designation>**.
 9. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture.
- C. Security Urinal - Stainless Steel, Back Access, Back Outlet, Trough :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations:
 - a. Obtain security urinals from single manufacturer.
4. Standards:
 - a. A112.19.3/CSA B45.4.
 - b. ASME A112.19.5/CSA B45.15.
 - c. ASME A112.6.1M.
 - d. ICC A117.1.
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Fixture:
 - a. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction.
 - b. Finish: Satin polished finish on exposed surfaces.
 - c. Type and Configuration: Washout, with back inlet, and **[36 inches (915 mm)][48 inches (1220 mm)][60 inches (1524 mm)][72 inches (1829 mm)][96 inches (2438 mm)]** wide.
 - d. Drain: Strainer with **NPS 2 (DN 50)** tailpiece and trap.
 - e. Features: **[ADA compliant]<Insert feature>**.
6. Mounting: Bolts through wall sleeve into accessible service space.
7. Mounting Height: **[Standard][Accessible]**.
8. Flushometer Valve: **<Insert designation>**.
9. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture.

D. Security Urinal - Stainless Steel, Bottom Outlet, Stall :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**

- b. [I-Con Systems, Inc.]
 - c. [Metcraft Industries, Inc.]
 - d. [Willoughby Industries, Inc.]
 - e. <Insert manufacturer's name>
- 3. Source Limitations:
 - a. Obtain security urinals from single manufacturer.
- 4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.19.5/CSA B45.15.
 - c. ASME A112.6.1M.
 - d. ICC A117.1.
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- 5. Fixture:
 - a. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction.
 - b. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
 - c. Type and Configuration: Washout, with back inlet.
 - d. Drain: Strainer with **NPS 2 (DN 50)** outlet.
- 6. Mounting: Bolts through wall into accessible service space.
- 7. Flushometer Valve: **<Insert designation>**.

2.5 SECURITY LAVATORIES

A. Security Lavatory - Stainless Steel, Back Access :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Acorn Engineering Company; a Division of Morris Group International]
 - b. [I-Con Systems, Inc.]
 - c. [Metcraft Industries, Inc.]
 - d. [Willoughby Industries, Inc.]
 - e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Acorn Engineering Company; a Division of Morris Group International]
 - b. [I-Con Systems, Inc.]
 - c. [Metcraft Industries, Inc.]
 - d. [Willoughby Industries, Inc.]
 - e. <Insert manufacturer's name>
- 3. Source Limitations:

- a. Obtain security lavatories from single manufacturer.
4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 - d. ASME A112.6.1M.
 - e. ICC A117.1.
 - f. NSF 61.
 - g. NSF 372.
 - h. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Fixture:
 - a. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction with fire-resistant sound-deadening material in cabinet interior.
 - b. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
 - c. Size: **<Insert dimensions>**.
 - d. Receptor: **[Oval][or][rectangular]** bowl with integral soap depression and backsplash.
 - e. Hot- and Cold-Water and Bubbler Supply Valves: **[Pneumatic, push-button, single-temperature, metering][Pneumatic, push-button, hot and cold, metering][Electronic, single-temperature, metering][Electronic, hot and cold, metering]** type with individual check stops, and **[backsplash-][or][deck-]**mounted filler spouts. Non-hold-open valve.
 - f. Drain: Integral punched grid with **NPS 1-1/4 (DN 32)** minimum horizontal waste and trap.
 - g. Features: **[ADA compliant][Ligature resistant][ADA compliant and ligature resistant]<Insert feature>**.
6. Accessories:
 - a. Toothbrush Holder: One on **[each][left][right]** side of backsplash.
 - b. Towel Hook: **[One][Two]** on **[each][left][right]** side of fixture.
 - c. Bubbler: Location on **[backsplash][deck]**.
7. Mounting: Bolts through wall into accessible service space.
8. Mounting Height: **[Standard][Accessible]**.

B. Security Lavatory - Stainless Steel, Front Access :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations:
 - a. Obtain security lavatories from single manufacturer.
4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 - d. ASME A112.6.1M.
 - e. ICC A117.1.
 - f. NSF 61.
 - g. NSF 372.
 - h. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Fixture:
 - a. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction with fire-resistant sound-deadening material in cabinet interior.
 - b. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
 - c. Size: **<Insert dimensions>**.
 - d. Receptor: **[Oval][or][rectangular]** bowl with integral soap depression, backsplash, and access panel.
 - e. Hot- and Cold-Water and Bubbler Supply Valves: **[Pneumatic, push-button, single-temperature, metering][Pneumatic, push-button, hot and cold, metering][Electronic, single-temperature, metering][Electronic, hot and cold, metering]** type with individual check stops, and **[backsplash-][or][deck-]**mounted filler spouts. Non-hold-open valve.
 - f. Drain: Integral punched grid with **NPS 1-1/4 (DN 32)** minimum horizontal waste and trap.
 - g. Features: **[ADA compliant][Ligature resistant][ADA compliant and ligature resistant]<Insert feature>**.
6. Accessories:
 - a. Toothbrush Holder: One on **[each][left][right]** side of backsplash.
 - b. Towel Hook: **[One][Two]** on **[each][left][right]** side of fixture.
 - c. Bubbler: Location on **[backsplash][deck]**.
7. Mounting: Bolts from fixture-mounted flanges into wall.
8. Mounting Height: **[Standard][Accessible]**.

2.6 SECURITY DRINKING FOUNTAINS

A. Security Drinking Fountain - Stainless Steel, Back Access :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [Acorn Engineering Company; a Division of Morris Group International]
 - b. [Metcraft Industries, Inc.]
 - c. [Willoughby Industries, Inc.]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Acorn Engineering Company; a Division of Morris Group International]
 - b. [Metcraft Industries, Inc.]
 - c. [Willoughby Industries, Inc.]
 - d. <Insert manufacturer's name>
3. Source Limitations:
 - a. Obtain security drinking fountains from single manufacturer.
4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 - d. ASME A112.6.1M.
 - e. ICC A117.1.
 - f. NSF 61.
 - g. NSF 372.
 - h. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Fixture:
 - a. Material: [14-gauge][12-gauge], Type 304 stainless steel, seamless welded construction with fire-resistant sound-deadening material in interior.
 - b. Finish: [Satin polished finish on exposed surfaces]<Insert finish>.
 - c. Receptor: Bowl with backsplash.
 - d. Bubbler Supply Valve: Push-button actuation and [backsplash-][or][deck-]mounted filler spouts.
 - e. Drain: Integral punched grid with NPS 1-1/4 (DN 32) tailpiece.
 - f. Features: [ADA compliant][Ligature resistant][ADA compliant and ligature resistant]<Insert feature>.
6. Waste Fitting: NPS 1-1/4 (DN 32) minimum waste and trap.
7. Mounting: Bolts through wall into accessible service space.
8. Mounting Height: [Standard][Accessible].
9. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture.

B. Security Drinking Fountain - Stainless Steel, Front Access :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Acorn Engineering Company; a Division of Morris Group International]

- b. **[Metcraft Industries, Inc.]**
 - c. **[Willoughby Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[Metcraft Industries, Inc.]**
 - c. **[Willoughby Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations:
 - a. Obtain security drinking fountains from single manufacturer.
4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 - d. ASME A112.6.1M.
 - e. ICC A117.1.
 - f. NSF 61.
 - g. NSF 372.
 - h. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Fixture:
 - a. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction with fire-resistant sound-deadening material in interior.
 - b. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
 - c. Receptor: Bowl with backsplash.
 - d. Bubbler Supply Valve: Push-button actuation and **[backsplash-][or][deck-]**mounted filler spouts.
 - e. Drain: Integral punched grid with **NPS 1-1/4 (DN 32)** tailpiece.
 - f. Features: **[ADA compliant][Ligature resistant][ADA compliant and ligature resistant]<Insert feature>**.
6. Waste Fitting: **NPS 1-1/4 (DN 32)** minimum waste and trap.
7. Mounting: Bolts from fixture-mounted flanges into wall.
8. Mounting Height: **[Standard][Accessible]**.

2.7 SECURITY SHOWERS

A. Security Shower - Stainless Steel, Back Access, Recessed :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**

- b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
- 3. Source Limitations:
 - a. Obtain security showers from single manufacturer.
- 4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASSE 1016.
 - d. ICC A117.1.
 - e. NSF 61.
 - f. NSF 372.
 - g. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- 5. Fixture:
 - a. Material: 14-gauge, Type 304 stainless steel, seamless welded construction.
 - b. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
 - c. Type and Configuration: Wall, with showerhead and soap dish.
 - d. Tempered Hot- and Cold-Water Supply Valves: **[Pneumatic, push-button, single-temperature, metering][Pneumatic, push-button, hot and cold, metering][Electronic, single-temperature, metering][Electronic, hot and cold, metering]** type with individual check stops. Non-hold-open valve. **[ADA compliant.]**
 - e. Shower: **[Hose with vandal-resistant, handheld][Vandal-resistant, fixed-type][Vandal-resistant, swivel-type]** head.
 - f. Soap Dish: Recessed, stainless steel.
 - g. Features: **[ADA compliant][Ligature resistant][ADA compliant and ligature resistant]<Insert feature>**.
- 6. Mounting: Bolts through wall sleeve into accessible service space.
- 7. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture.

B. Security Shower - Stainless Steel, Front Access, Recessed :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations:
 - a. Obtain security showers from single manufacturer.
 4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASSE 1016.
 - d. ICC A117.1.
 - e. NSF 61.
 - f. NSF 372.
 - g. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
 5. Fixture:
 - a. Material: 14-gauge, Type 304 stainless steel, seamless welded construction.
 - b. Finish: **[Satin polished finish on exposed surfaces]<Insert finish>**.
 - c. Type and Configuration: Wall, with showerhead and soap dish.
 - d. Tempered Hot- and Cold-Water Supply Valves: **[Pneumatic, push-button, single-temperature, metering][Pneumatic, push-button, hot and cold, metering][Electronic, single-temperature, metering][Electronic, hot and cold, metering]** type with individual check stops. Non-hold-open valve. **[ADA compliant.]**
 - e. Shower: **[Hose with vandal-resistant, handheld][Vandal-resistant, fixed-type][Vandal-resistant, swivel-type]** head.
 - f. Soap Dish: Recessed, stainless steel.
 - g. Access to Internal Components: Vandal-resistant access panels.
 - h. Features: **[ADA compliant][Ligature resistant][ADA compliant and ligature resistant]<Insert feature>**.
 6. Mounting: Bolts from fixture-mounted flanges into wall.
- C. Security Shower - Stainless Steel, Front Access, Surface Mounted :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [I-Con Systems, Inc.]
 - b. [Metcraft Industries, Inc.]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [I-Con Systems, Inc.]
 - b. [Metcraft Industries, Inc.]
 - c. <Insert manufacturer's name>
3. Source Limitations:
 - a. Obtain security showers from single manufacturer.
4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASSE 1016.
 - d. ICC A117.1.
 - e. NSF 61.
 - f. NSF 372.
 - g. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Fixture:
 - a. Material: 14-gauge, Type 304 stainless steel, seamless welded construction.
 - b. Finish: [Satin polished finish on exposed surfaces]<Insert finish>.
 - c. Type and Configuration: Wall, with showerhead and soap dish.
 - d. Tempered Hot- and Cold-Water-Water Supply Valves: [Pneumatic, push-button, single-temperature, metering][Pneumatic, push-button, hot and cold, metering][Electronic, single-temperature, metering][Electronic, hot and cold, metering] type with individual check stops. Non-hold-open valve.[ADA compliant.]
 - e. Soap Dish: Recessed, stainless steel.
 - f. Access to Internal Components: Vandal-resistant access panels.
 - g. Features: [ADA compliant][Ligature resistant][ADA compliant and ligature resistant]<Insert feature>.
6. Mounting: Bolts from fixture-mounted flanges into wall.

D. Security Shower - Stainless Steel, Back or Front Access, Accessible, Cabinet :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Acorn Engineering Company; a Division of Morris Group International]
 - b. [I-Con Systems, Inc.]
 - c. [Metcraft Industries, Inc.]
 - d. [Willoughby Industries, Inc.]
 - e. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations:
 - a. Obtain security showers from single manufacturer.
 4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 - d. ASSE 1016.
 - e. ICC A117.1.
 - f. NSF 61.
 - g. NSF 372.
 - h. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
 5. Fixture:
 - a. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction.
 - b. Finish: Satin polished finish on exposed surfaces. Slip-resistant shower floor.
 - c. Configuration: **[Back][Front]** access.
 - d. Type and Configuration: Cabinet **[36 by 36 inches (915 by 915 mm)][36 by 60 inches (915 by 1524 mm)]<Insert dimensions>** with floor **[and top]**, and with stainless steel soap dish, towel hook, drain, seat, and grab bar.
 - e. Tempered Hot- and Cold-Water-Water Supply Valves: Mechanical-metering type with individual check stops.
 - f. Shower: Hose with vandal-resistant, handheld head.
 - g. Drain: Grid with **NPS 2 (DN 50)** outlet.
 - h. Features: **[Ligature resistant]<Insert feature>**.
 6. Waste Fitting: **NPS 2 (DN 50)** waste to wall; trap.
 7. Mounting: Bolts through wall into accessible service space.
- E. Security Shower - Stainless Steel, Back or Front Access, Cabinet :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[I-Con Systems, Inc.]**
 - c. **[Metcraft Industries, Inc.]**
 - d. **[Willoughby Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations:
 - a. Obtain security showers from single manufacturer.
4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 - d. ASSE 1016.
 - e. NSF 61.
 - f. NSF 372.
 - g. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Fixture:
 - a. Material: **[14-gauge][12-gauge]**, Type 304 stainless steel, seamless welded construction.
 - b. Finish: Satin polished finish on exposed surfaces. Slip-resistant shower floor.
 - c. Configuration: **[Back][Front]** access.
 - d. Cabinet: **[30 by 30 inches (760 by 760 mm)][32 by 32 inches (815 by 815 mm)][36 by 36 inches (915 by 915 mm)]<Insert dimensions>** with floor **[and top]**, and with stainless steel soap dish, towel hook, and drain.
 - e. Tempered Hot- and Cold-Water Supply Valves: Mechanical-metering type with individual check stops.
 - f. Shower: **[Vandal-resistant, fixed][Fixed][Swivel]**-type head.
 - g. Drain: Grid with **NPS 2 (DN 50)** outlet.
 - h. Features: **[Ligature resistant]<Insert feature>**.
6. Waste Fitting: **NPS 2 (DN 50)** elbow waste.
7. Mounting: Bolts through wall into accessible service space.

2.8 SECURITY SERVICE SINKS

A. Security Service Sink - Stainless Steel, Back or Front Access, On or Off Floor :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acorn Engineering Company; a Division of Morris Group International]**
 - b. **[Metcraft Industries, Inc.]**
 - c. **[Willoughby Industries, Inc.]**

- d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Acorn Engineering Company; a Division of Morris Group International]
 - b. [Metcraft Industries, Inc.]
 - c. [Willoughby Industries, Inc.]
 - d. <Insert manufacturer's name>
3. Source Limitations:
 - a. Obtain security service sinks from single manufacturer.
4. Standards:
 - a. ASME A112.19.3/CSA B45.4.
 - b. ASME A112.18.1/CSA B125.1.
 - c. ASME A112.18.2/CSA B125.2.
 - d. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Fixture:
 - a. Material: [14-gauge][12-gauge], Type 304 stainless steel, seamless welded construction.
 - b. Finish: Satin polished finish on exposed surfaces.
 - c. Configuration: [Back][Front] access, [on][off] floor.
 - d. Receptor: Rectangular bowl with high backsplash.
 - e. Nominal Size: [20 by 19 inches (508 by 483 mm)][24 by 19 inches (610 by 483 mm)]<Insert dimensions>.
 - f. Hot- and Cold-Water Supply Valves: Push-button actuation and backsplash-mounted filler spout with [hose][plain] end.
 - g. Drain: Grid with NPS 2 (DN 50) outlet.
6. Waste Fitting: NPS 2 (DN 50) elbow waste.
7. Mounting: Bolts through wall into accessible service space.
8. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture.

2.9 FLUSHOMETER VALVES

A. Flushometer Valve - Diaphragm :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Advanced Modern Technologies Corporation - AMTC]
 - b. [Delany Products]
 - c. [Sloan Valve Company]
 - d. [Zurn Industries, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Advanced Modern Technologies Corporation - AMTC]**
 - b. **[Delany Products]**
 - c. **[Sloan Valve Company]**
 - d. **[Zurn Industries, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations:
- a. Obtain flushometer valves from single manufacturer.
4. Standards:
- a. ASSE 1037/ASME A112.1037/CSA B125.37
 - b. ASME A112.19.5/CSA B45.15.
 - c. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
5. Minimum Pressure Rating: **125 psig (860 kPa)**.
6. Features: Integral check stops and backflow-prevention device.
7. Material: Brass body with corrosion-resistant components.
8. Actuator: **[Lever handle][Hydraulic, push button][Solenoid, battery powered][Solenoid, hard wired]**.
9. Trip Mechanism: **[Battery-powered][Hard-wired]** electronic sensor, listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
10. Style: Concealed.
11. Finish: Panel and exposed surfaces, chrome plated or stainless steel.
12. Consumption: **[1.6 gal. (6 L)][1.28 gal. (4.8 L)][1.1 gal. (4.2 L)][1.0 gal. (3.8 L)][0.5 gal. (1.9 L)][0.125 gal. (0.5 L)]** per flush.
13. Minimum Inlet: **[NPS 1 (DN 25)][NPS 3/4 (DN 20)]**.
14. Minimum Outlet: **[NPS 1-1/4 (DN 32)][NPS 3/4 (DN 20)]**.

2.10 TOILET SEATS

A. Toilet Seat :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Standard]**
 - b. **[Bemis Manufacturing Company]**
 - c. **[Centoco Manufacturing Corporation]**
 - d. **[Church Seats; Bemis Manufacturing Company]**
 - e. **[Jones Stephens Corp.]**
 - f. **[Kohler Co]**
 - g. **[Zurn Industries, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. **[American Standard]**
 - b. **[Bemis Manufacturing Company]**
 - c. **[Centoco Manufacturing Corporation]**
 - d. **[Church Seats; Bemis Manufacturing Company]**
 - e. **[Jones Stephens Corp.]**
 - f. **[Kohler Co]**
 - g. **[Zurn Industries, LLC]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations:
- a. Obtain toilet seats from single manufacturer.
4. Material: Plastic.
5. Type: Commercial, heavy duty.
- a. Shape: Elongated rim, **[open][closed]** front.
 - b. Hinge: **[Check][Self-sustaining check]**.
 - c. Hinge Material: Noncorroding metal.
 - d. Seat Cover: **[Required][Not required]**.
 - e. Color: **[White][Black]**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.
- B. Examine walls and floors for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SECURITY PLUMBING FIXTURES

- A. Install security plumbing fixtures level and plumb.
- B. Install back-access, stainless steel fixtures as follows:
 1. Install wall sleeve in wall if indicated.
 2. Install fixture on wall sleeve or wall, as indicated, with access from accessible service space.
 3. Extend supply piping from service space to fixture.
 4. Install soil and waste piping from fixture and extend into service space.
 5. Install fixture trap in service space instead of below fixture drain.
- C. Install front-access, stainless steel fixtures as follows:
 1. Install fixture support or mounting bracket.
 2. Install fixture on support; mount components inside of or attached to fixture.
 3. Extend supply piping from pipe space to fixture.

4. Install trap below fixture and extend soil and waste piping into pipe space.

- D. Install fixture outlets with gasket seals.
- E. Install fixtures designated "accessible" in accordance with ICC A117.1 for heights, dimensions, and clearances.
- F. Install toilet seats on **[water closets][and][combination units]** if seats are indicated.
- G. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible fixtures. Comply with requirements in Section 220719 "Plumbing Piping Insulation."
- H. Seal joints between fixtures, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
- I. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."

3.3 PIPING CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with requirements for water piping specified in Section 221116 "Domestic Water Piping."
- C. Comply with requirements for soil and waste drainage piping specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **[1/2 inch (13 mm)]<Insert dimension>** high.

3.5 ADJUSTING

- A. Operate and adjust flushometer valves and flow-control valves on fixtures. Replace damaged and

malfunctioning fixtures, fittings, and controls.

- B. Adjust water pressure at fixtures to produce proper flow.
- C. Install new batteries in battery-powered, electronic-sensor mechanisms.

3.6 CLEANING AND PROTECTION

- A. After installing fixtures, inspect and replace damaged finishes.
- B. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed fixtures and fittings.
- D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 46 00 00

THIS PAGE INTENTIONALLY LEFT BLANK



Task	Specification	Specification Description
22 46 13 00	22 46 00 00	Security Plumbing Fixtures
22 46 13 13	22 46 00 00	Security Plumbing Fixtures
22 46 13 16	22 46 00 00	Security Plumbing Fixtures
22 46 13 19	22 46 00 00	Security Plumbing Fixtures
22 46 16 00	22 46 00 00	Security Plumbing Fixtures
22 46 16 13	22 46 00 00	Security Plumbing Fixtures
22 46 16 16	22 46 00 00	Security Plumbing Fixtures
22 46 19 00	22 46 00 00	Security Plumbing Fixtures
22 46 43 00	22 46 00 00	Security Plumbing Fixtures
22 46 56 00	22 46 00 00	Security Plumbing Fixtures



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 47 00 00 - DRINKING FOUNTAINS AND WATER COOLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Drinking fountains.
2. Water coolers.
3. Bottle filling stations.
4. Remote water coolers.
5. Fixture carriers.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - b. Include operating characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of fixture assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power wiring.

C. Delegated Design Submittals: For vibration isolation[**and supports,**][, **and seismic restraints**] indicated to comply with performance requirements and design criteria, including analysis data **[signed and sealed by the qualified professional engineer responsible for their preparation]**.

D. Sustainable Design Submittals:

1. Product Data: For water consumption.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For remote water coolers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For **[drinking fountains,][water coolers,][bottle filling stations,][and][remote water coolers]** to include in maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include servicing and adjustment of electronic-sensor fixtures.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filter Cartridges: Equal to **<Insert number>** percent of quantity installed for each type and size indicated, but no fewer than **<Insert number>** of each.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's written instructions for delivery, storage, and handling.

1.7 WARRANTY

- A. Manufacturer Warranty: **[Manufacturer agrees][Installer agrees][Manufacturer and Installer agree]** to repair or replace **[drinking fountains][water coolers][bottle filling stations][remote water coolers]** that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Faulty operation of **<Insert type of failure>**.
 - b. Deterioration of metals, metal finishes, and other materials beyond normal **[weathering][use]**.
- B. Warranty Period: **[One]<number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Standards:
 - 1. Drinking fountains, water coolers, bottle filling stations, and remote water coolers intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), requirements of the authority having jurisdiction, and with NSF 61 or NSF 372, or be certified in compliance with NSF 61 or NSF 372 by an ANSI-accredited third-party certification body, that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
- B. Delegated Design:

1. **[Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to]** design vibration isolation[, supports,][**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 2. **[Product manufacturer's qualified staff][Qualified professional engineer employed by the product manufacturer]** to select and size products to achieve specified performance requirements.
- C. Seismic Performance: Remote water coolers are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**. See **[Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"]<Insert Section>**.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 DRINKING FOUNTAINS

- A. Drinking Fountains - Surface Wall Mounted, Bronze :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Filtrine Manufacturing Company]**
 - b. **[Murdock Manufacturing; A Division of Morris Group International]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Filtrine Manufacturing Company]**
 - b. **[Murdock Manufacturing; A Division of Morris Group International]**
 - c. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain surface wall-mounted, bronze drinking fountains from single source from single manufacturer.
 4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 5. Type: **[Vandal resistant][and][freeze resistant]**.
 6. Receptor(s):
 - a. Type: **[Slab][With back][On horizontal support]**.
 - b. Shape: **[Rectangular][Round]<Insert shape>**.
 - c. Back Panel: **[Stainless steel]<Insert material>** wall plate behind drinking fountain.
 - d. Bubblers: One for each receptor, with adjustable stream regulator, located on deck.
 - e. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.

7. Maximum Water Flow: **[0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>**.
8. Control: **[Push button][Push bar][Sensor]<Insert control>**.
9. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
10. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** chrome-plated brass P-trap and waste.
11. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
12. Electrical Characteristics:
 - a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - b. Volts: 120 V ac.
 - c. Phase: Single.
 - d. Hertz: 60 Hz.
13. Support: Provide manufacturer's mounting plate.
14. Drinking Fountain Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1]**.
15. Freeze-Resistant Supply Fittings: Through wall freeze-resistant shutoff and flow-control valve assembly.

B. Drinking Fountains - Surface Wall Mounted, Enameled Cast Iron :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Murdock Manufacturing; A Division of Morris Group International]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Murdock Manufacturing; A Division of Morris Group International]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain surface wall-mounted, enameled cast iron drinking fountains from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
5. Type: **[Vandal resistant][and][freeze resistant]**.
6. Receptor(s):
 - a. Type: **[Slab][With back][On horizontal support]**.
 - b. Shape: **[Rectangular][Round]<Insert shape>**.

- c. Color: White.
 - d. Back Panel: **[Stainless steel]<Insert material>** wall plate behind drinking fountain.
 - e. Bubblers: One for each receptor, with adjustable stream regulator, located on deck.
 - f. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
- 7. Maximum Water Flow: **[0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>**.
 - 8. Control: Push button.
 - 9. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
 - 10. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** chrome-plated brass P-trap and waste.
 - 11. Filter: One or more water filters with capacity sized for unit peak flow rate.
- a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
- 12. Support: Provide manufacturer's mounting plate.
 - 13. Drinking Fountain Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1]**.
 - 14. Freeze-Resistant Supply Fittings: Through wall freeze-resistant shutoff and flow-control valve assembly.

C. Drinking Fountains - Surface Wall Mounted, Composite/Granite :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elkay]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain surface wall-mounted, composite/granite drinking fountains from single source from single manufacturer.
- 4. Standards:
 - a. NSF 61.
 - b. NSF 372.
- 5. Type: **[Vandal resistant][and][freeze resistant]**.
- 6. Receptor(s):
 - a. Type: **[Slab][With back][On horizontal support]**.
 - b. Shape: Rectangular.
 - c. Back Panel: **[Stainless steel]<Insert material>** wall plate behind drinking fountain.
 - d. Bubblers: One for each receptor, with adjustable stream regulator, located on deck.
 - e. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.



7. Maximum Water Flow: **[0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>**.
8. Control: Push button.
9. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
10. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** chrome-plated brass P-trap and waste.
11. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
12. Support: Provide manufacturer's mounting plate.
13. Drinking Fountain Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1]**.
14. Freeze-Resistant Supply Fittings: Through wall freeze-resistant shutoff and flow-control valve assembly.

D. Drinking Fountains - Surface Wall Mounted, Concrete :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Haws Corporation]**
 - b. **[Murdock Manufacturing; A Division of Morris Group International]**
 - c. **[Petersen Manufacturing Co. Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Haws Corporation]**
 - b. **[Murdock Manufacturing; A Division of Morris Group International]**
 - c. **[Petersen Manufacturing Co. Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain surface wall-mounted, concrete drinking fountains from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
5. Type: **[Vandal resistant][and][freeze resistant]**.
6. Receptor(s):
 - a. Type: **[Slab][With back][On horizontal support]**.
 - b. Shape: **[Rectangular][Round]<Insert shape>**.
 - c. Back Panel: **[Stainless steel]<Insert material>** wall plate behind drinking fountain.
 - d. Bubblers: One for each receptor, with adjustable stream regulator, located on deck.
 - e. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.

7. Maximum Water Flow: [0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>.
8. Control: Push button.
9. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
10. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** chrome-plated brass P-trap and waste.
11. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
12. Support: Provide manufacturer's mounting plate.
13. Drinking Fountain Mounting Height: [Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1].
14. Freeze-Resistant Supply Fittings: Through wall freeze-resistant shutoff and flow-control valve assembly.

E. Drinking Fountains - Surface Wall Mounted, Powder-Coated Metal :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Halsey Taylor]
 - b. [Haws Corporation]
 - c. [Most Dependable Fountains, Inc.]
 - d. [Oasis International]
 - e. [Stern-Williams Products, LLC.]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Halsey Taylor]
 - b. [Haws Corporation]
 - c. [Most Dependable Fountains, Inc.]
 - d. [Oasis International]
 - e. [Stern-Williams Products, LLC.]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain surface wall-mounted, powder-coated-metal drinking fountains from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
5. Type: [Vandal resistant][and][freeze resistant].
6. Receptor(s):
 - a. Type: [Slab][With back][On horizontal support].
 - b. Shape: [Rectangular][Round]<Insert shape>.
 - c. Back Panel: [Stainless steel]<Insert material> wall plate behind drinking fountain.



- d. Bubblers: One for each receptor, with adjustable stream regulator, located on deck.
- e. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
- 7. Maximum Water Flow: **[0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>**.
- 8. Control: Push button.
- 9. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
- 10. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** chrome-plated brass P-trap and waste.
- 11. Filter: One or more water filters with capacity sized for unit peak flow rate.
- a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
- 12. Support: Provide manufacturer's mounting plate.
- 13. Drinking Fountain Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1]**.
- 14. Freeze-Resistant Supply Fittings: Through wall freeze-resistant shutoff and flow-control valve assembly.

F. Drinking Fountains - Surface Wall Mounted, Stainless Steel :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elkay]**
 - b. **[Filtrine Manufacturing Company]**
 - c. **[Haws Corporation]**
 - d. **[Most Dependable Fountains, Inc.]**
 - e. **[Murdock Manufacturing; A Division of Morris Group International]**
 - f. **[Oasis International]**
 - g. **[Stern-Williams Products, LLC.]**
 - h. **[Willoughby Industries, Inc.]**
 - i. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **[Filtrine Manufacturing Company]**
 - c. **[Haws Corporation]**
 - d. **[Most Dependable Fountains, Inc.]**
 - e. **[Murdock Manufacturing; A Division of Morris Group International]**
 - f. **[Oasis International]**
 - g. **[Stern-Williams Products, LLC.]**
 - h. **[Willoughby Industries, Inc.]**
 - i. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain surface wall-mounted, stainless steel drinking fountains from single source from single manufacturer.
- 4. Standards:

- a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
5. Type: **[Vandal resistant][and][freeze resistant]**.
6. Receptor(s):
 - a. Type: **[Slab][With back][On horizontal support]**.
 - b. Shape: **[Rectangular][Round]<Insert shape>**.
 - c. Back Panel: **[Stainless steel]<Insert material>** wall plate behind drinking fountain.
 - d. Bubblers: One for each receptor, with adjustable stream regulator, located on deck.
 - e. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
7. Maximum Water Flow: **[0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>**.
8. Control: **[Push button][Push bar][Sensor]<Insert control>**.
9. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
10. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** chrome-plated brass P-trap and waste.
11. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
12. Electrical Characteristics:
 - a. Standard: Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - b. Volts: 120 V ac.
 - c. Phase: Single.
 - d. Hertz: 60 Hz.
13. Support: Provide manufacturer's mounting plate.
14. Drinking Fountain Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1]**.
15. Freeze-Resistant Supply Fittings: Through wall freeze-resistant shutoff and flow-control valve assembly.

G. Drinking Fountains - Surface Wall Mounted, Stone Aggregate/Terrazzo :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elkay]**
 - b. **[Stern-Williams Products, LLC.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**

- b. **[Stern-Williams Products, LLC.]**
- c. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain surface wall-mounted, stone aggregate/terrazzo drinking fountains from single source from single manufacturer.
- 4. Standards:
 - a. NSF 61.
 - b. NSF 372.
- 5. Type: **[Vandal resistant][and][freeze resistant]**.
- 6. Receptor(s):
 - a. Type: **[Slab][With back][On horizontal support]**.
 - b. Shape: **[Rectangular][Round]<Insert shape>**.
 - c. Back Panel: **[Stainless steel]<Insert material>** wall plate behind drinking fountain.
 - d. Bubblers: One for each receptor, with adjustable stream regulator, located on deck.
 - e. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
- 7. Maximum Water Flow: **[0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>**.
- 8. Control: Push button.
- 9. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
- 10. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** chrome-plated brass P-trap and waste.
- 11. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
- 12. Support: Provide manufacturer's mounting plate.
- 13. Drinking Fountain Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1]**.
- 14. Freeze-Resistant Supply Fittings: Through wall freeze-resistant shutoff and flow-control valve assembly.

H. Drinking Fountains - Semi-Recessed, Wall Mounted, Stainless Steel :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elkay]**
 - b. **[Filtrine Manufacturing Company]**
 - c. **[Oasis International]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **[Filtrine Manufacturing Company]**

- c. **[Oasis International]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain semi-recessed, wall-mounted, stainless steel drinking fountains from single source from single manufacturer.
 4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
 5. Receptor Shape: Concave with projecting bowl.
 6. Bubbler: One, with adjustable stream regulator, located on deck.
 7. Maximum Water Flow: **[0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>**.
 8. Control: **[Push button][Push bar]<Insert control>**.
 9. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
 10. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
 11. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
 12. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
 13. Support: Manufacturer-provided support frame for attaching to substrate.
 14. Drinking Fountain Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
- I. Drinking Fountains - Recessed, Wall Mounted, Bronze :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Filtrine Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Filtrine Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain recessed, wall-mounted, bronze drinking fountains from single source from single manufacturer.
 4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 5. Receptor Shape: Concave with flush wall flange.
 6. Bubbler: One, with adjustable stream regulator, located on deck.
 7. Maximum Water Flow: **[0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>**.

8. Control: Push button.
9. Drain: Grid with **NPS 1-1/4 (DN 32)** minimum horizontal waste and trap, complying with ASME A112.18.2/CSA B125.2.
10. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
11. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
12. Filter: One or more water filters with capacity sized for unit peak flow rate.

a. Standards:

- 1) NSF 42.
- 2) NSF 53.

13. Support: Provide manufacturer's support frame attached to substrate.
14. Drinking Fountain Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.

J. Drinking Fountains - Recessed, Wall Mounted, Stainless Steel :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elkay]**
 - b. **[Filtrine Manufacturing Company]**
 - c. **[Murdock Manufacturing; A Division of Morris Group International]**
 - d. **[Oasis International]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **[Filtrine Manufacturing Company]**
 - c. **[Murdock Manufacturing; A Division of Morris Group International]**
 - d. **[Oasis International]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain recessed, wall-mounted, stainless steel drinking fountains from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
5. Receptor Shape: Concave with flush wall flange.
6. Bubbler: One, with adjustable stream regulator, located on deck.
7. Maximum Water Flow: **[0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>**.
8. Control: **[Push button][or][Push bar]<Insert control>**.
9. Drain: Grid with **NPS 1-1/4 (DN 32)** minimum horizontal waste and trap, complying with ASME A112.18.2/CSA B125.2.
10. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
11. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.

12. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
13. Support: Provide manufacturer's support frame attached to substrate.
14. Drinking Fountain Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.

K. Drinking Fountains - Pedestal, Concrete :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Haws Corporation]**
 - b. **[Murdock Manufacturing; A Division of Morris Group International]**
 - c. **[Petersen Manufacturing Co. Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Haws Corporation]**
 - b. **[Murdock Manufacturing; A Division of Morris Group International]**
 - c. **[Petersen Manufacturing Co. Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain pedestal, concrete drinking fountains from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
5. Type: **[Vandal resistant][and][freeze resistant]**.
6. Pedestal: **[Rectangular][Round]<Insert shape>**.
7. Receptor(s):
 - a. Shape: **[Rectangular][Round]<Insert shape>**.
 - b. Bubbler: One for each receptor, with adjustable stream regulator, located on deck.
 - c. Bottle Filler: Push-button activation.
 - d. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
8. Maximum Water Flow: **[0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>**.
9. Control: Push button.
10. Access to Internal Components: Panel in pedestal.
11. Supply: **[NPS 3/8 (DN 10)][NPS 1/2 (DN 15)]** with shutoff valve.
12. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:

- 1) NSF 42.
- 2) NSF 53.

13. Drain Piping: **[NPS 1-1/4 (DN 32)][NPS 1-1/2 (DN 40)]** minimum trap and waste.
14. Drinking Fountain Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1].**
15. Freeze-Resistant Supply Fittings: Underground freeze-resistant shutoff and flow-control valve assembly.
16. Bury Depth, Grade to Valve Components: **[36 inches (915 mm)][48 inches (1220 mm)][60 inches (1525 mm)]<Insert dimension>.**

L. Drinking Fountains - Pedestal, Powder-Coated Metal :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Halsey Taylor]**
 - b. **[Haws Corporation]**
 - c. **[Most Dependable Fountains, Inc.]**
 - d. **[Murdock Manufacturing; A Division of Morris Group International]**
 - e. **[Stern-Williams Products, LLC.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Halsey Taylor]**
 - b. **[Haws Corporation]**
 - c. **[Most Dependable Fountains, Inc.]**
 - d. **[Murdock Manufacturing; A Division of Morris Group International]**
 - e. **[Stern-Williams Products, LLC.]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain pedestal, powder-coated-metal drinking fountains from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
5. Type: **[Vandal resistant][and][freeze resistant].**
6. Pedestal: **[Rectangular][Round]<Insert shape>.**
7. Receptor(s):
 - a. Shape: **[Rectangular][Round]<Insert shape>.**
 - b. Bubbler: One for each receptor, with adjustable stream regulator, located on deck.
 - c. Bottle Filler: Push-button activation.
 - d. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
8. Maximum Water Flow: **[0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>.**
9. Controls: Push button.
10. Access to Internal Components: Panel in pedestal.

11. Supply: **[NPS 3/8 (DN 10)][NPS 1/2 (DN 15)]** with shutoff valve.
12. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
13. Drain Piping: **[NPS 1-1/4 (DN 32)][NPS 1-1/2 (DN 40)]** minimum trap and waste.
14. Drinking Fountain Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1].**
15. Freeze-Resistant Supply Fittings: Underground freeze-resistant shutoff and flow-control valve assembly.
16. Bury Depth, Grade to Valve Components: **[36 inches (915 mm)][48 inches (1220 mm)][60 inches (1525 mm)]<Insert dimension>.**

M. Drinking Fountains - Pedestal, Stainless Steel :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Haws Corporation]**
 - b. **[Most Dependable Fountains, Inc.]**
 - c. **[Murdock Manufacturing; A Division of Morris Group International]**
 - d. **[Stern-Williams Products, LLC.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Haws Corporation]**
 - b. **[Most Dependable Fountains, Inc.]**
 - c. **[Murdock Manufacturing; A Division of Morris Group International]**
 - d. **[Stern-Williams Products, LLC.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain pedestal, stainless steel drinking fountains from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
5. Type: **[Vandal resistant][and][freeze resistant].**
6. Pedestal: **[Rectangular][Round]<Insert shape>.**
7. Receptor(s):
 - a. Shape: **[Rectangular][Round]<Insert shape>.**
 - b. Bubbler: One for each receptor, with adjustable stream regulator, located on deck.
 - c. Bottle Filler: Push-button activation.
 - d. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.

8. Maximum Water Flow: [0.15 gpm (0.0095 L/s)][0.5 gpm (0.0316 L/s)]<Insert value>.
9. Controls: Push button.
10. Access to Internal Components: Panel in pedestal.
11. Supply: [NPS 3/8 (DN 10)][NPS 1/2 (DN 15)] with shutoff valve.
12. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
13. Drain Piping: [NPS 1-1/4 (DN 32)][NPS 1-1/2 (DN 40)] minimum trap and waste.
14. Drinking Fountain Height: [Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1].
15. Freeze-Resistant Supply Fittings: Underground freeze-resistant shutoff and flow-control valve assembly.
16. Bury Depth, Grade to Valve Components: [36 inches (915 mm)][48 inches (1220 mm)][60 inches (1525 mm)]<Insert dimension>.

2.3 WATER COOLERS

A. Water Coolers - Freestanding, Floor Mounted, Single Station, Stainless Steel :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Elkay]
 - b. [Murdock Manufacturing; A Division of Morris Group International]
 - c. [Oasis International]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Elkay]
 - b. [Murdock Manufacturing; A Division of Morris Group International]
 - c. [Oasis International]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain freestanding, floor-mounted, single-station, stainless steel water coolers from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
 - d. ASHRAE 18.
 - e. UL 399.
 - f. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

5. Bubbler: One, with adjustable stream regulator, located on deck.
6. Control: **[Push button][Foot pedal]<Insert control>**.
7. Drain: Grid with **NPS 1-1/4 (DN 32)** tailpiece.
8. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
9. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
10. Cooling System: Electric, with **[precooler,]** hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
11. Glass filler.
12. Filter: One or more water filters with capacity sized for unit peak flow rate.

a. Standards:

- 1) NSF 42.
- 2) NSF 53.

13. Capacities and Characteristics:

- a. Cooled Water: **[5 gph (0.0053 L/s)][8 gph (0.0084 L/s)][10 gph (0.0105 L/s)][14 gph (0.0147 L/s)]<Insert value>**.
- b. Ambient-Air Temperature: **90 deg F (32 deg C)**.
- c. Inlet-Water Temperature: **80 deg F (27 deg C)**.
- d. Cooled-Water Temperature: **50 deg F (10 deg C)**.
- e. Cooled-Water Storage: **<Insert gal. (L)>**.
- f. Electrical Characteristics:
 - 1) Motor Horsepower: **[1/6][1/5][1/4]<Insert value>**.
 - 2) Volts: 120 V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60 Hz.
 - 5) Full-Load Amperes: **<Insert value> A**.
 - 6) Minimum Circuit Ampacity: **<Insert value> A**.
 - 7) Maximum Overcurrent Protection: **<Insert value> A**.

B. Water Coolers - Freestanding, Floor Mounted, Single Station, Powder-Coated Metal :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Murdock Manufacturing; A Division of Morris Group International]**
 - b. **[Oasis International]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Murdock Manufacturing; A Division of Morris Group International]**
 - b. **[Oasis International]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain freestanding, floor-mounted, single-station, powder-coated-metal water coolers from single source from single manufacturer.
4. Standards:

- a. NSF 61.
 - b. NSF 372.
 - c. ASHRAE 18.
 - d. UL 399.
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Bubbler: One, with adjustable stream regulator, located on deck.
 6. Control: **[Push button][Foot pedal]<Insert control>**.
 7. Drain: Grid with **NPS 1-1/4 (DN 32)** tailpiece.
 8. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
 9. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
 10. Cooling System: Electric, with **[precooler,]** hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 11. Glass filler.
 12. Filter: One or more water filters with capacity sized for unit peak flow rate.

a. Standards:

- 1) NSF 42.
- 2) NSF 53.

13. Capacities and Characteristics:

- a. Cooled Water: **[5 gph (0.0053 L/s)][8 gph (0.0084 L/s)][10 gph (0.0105 L/s)][14 gph (0.0147 L/s)]<Insert value>**.
- b. Ambient-Air Temperature: **90 deg F (32 deg C)**.
- c. Inlet-Water Temperature: **80 deg F (27 deg C)**.
- d. Cooled-Water Temperature: **50 deg F (10 deg C)**.
- e. Cooled-Water Storage: **<Insert gal. (L)>**.
- f. Electrical Characteristics:
 - 1) Motor Horsepower: **[1/6][1/5][1/4]<Insert value>**.
 - 2) Volts: 120 V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60 Hz.
 - 5) Full-Load Amperes: **<Insert value> A**.
 - 6) Minimum Circuit Ampacity: **<Insert value> A**.
 - 7) Maximum Overcurrent Protection: **<Insert value> A**.

C. Water Coolers - Surface Wall Mounted, Stainless Steel :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **[Murdock Manufacturing; A Division of Morris Group International]**
 - d. **[Oasis International]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **[Murdock Manufacturing; A Division of Morris Group International]**
 - d. **[Oasis International]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain surface wall-mounted, stainless steel, water coolers from single source from single manufacturer.
4. Standards:
- a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
 - d. ASHRAE 18.
 - e. UL 399.
 - f. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Type: **[Vandal resistant][and][freeze resistant]**.
6. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
7. Control: **[Push button][Push bar][Sensor]<Insert control>**.
8. Glass filler.
9. Bottle Filler: **[Sensor][Push-button]** activation[, with]**[20-second]<Insert value>****[automatic shutoff timer]**: Fill rate is **[0.5 to 1.5 gpm (0.03155 to 0.09464 L/s)]<Insert value>**.
10. Drain: Grid with **NPS 1-1/4 (DN 32)** tailpiece.
11. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
12. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
13. Filter: One or more water filters with capacity sized for unit peak flow rate.
- a. Standards:
- 1) NSF 42.
 - 2) NSF 53.
14. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
15. Support: Fixture carrier.
16. Water-Cooler Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1]**.
17. Capacities and Characteristics:
- a. Cooled Water: **[5 gph (0.0053 L/s)][8 gph (0.0084 L/s)]<Insert value>**.
 - b. Ambient-Air Temperature: **90 deg F (32 deg C)**.
 - c. Inlet-Water Temperature: **80 deg F (27 deg C)**.
 - d. Cooled-Water Temperature: **50 deg F (10 deg C)**.
 - e. Cooled-Water Storage: **<Insert value>**.
 - f. Electrical Characteristics:
 - 1) Motor Horsepower: **[1/6][1/5][1/4][1/3]<Insert value>**.
 - 2) Volts: 120 V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60 Hz.

- 5) Full-Load Amperes: **<Insert value> A.**
- 6) Minimum Circuit Ampacity: **<Insert value> A.**
- 7) Maximum Overcurrent Protection: **<Insert value> A.**

D. Water Coolers - Surface Wall Mounted, Powder-Coated Metal :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Elkay]**
 - b. **[Murdock Manufacturing; A Division of Morris Group International]**
 - c. **[Oasis International]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **[Murdock Manufacturing; A Division of Morris Group International]**
 - c. **[Oasis International]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain surface wall-mounted, powder-coated-metal, water coolers from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASHRAE 18.
 - d. UL 399.
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Color: Gray.
6. Type: **[Vandal resistant][and][freeze resistant].**
7. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
8. Control: **[Push button][Push bar][Sensor]<Insert control>.**
9. Glass filler.
10. Bottle Filler: **[Sensor][Push-button]** activation[, with]**[20-second]<Insert value>[automatic shutoff timer]:** Fill rate is **[0.5 to 1.5 gpm (0.03155 to 0.09464 L/s)]<Insert value>.**
11. Drain: Grid with **NPS 1-1/4 (DN 32)** tailpiece.
12. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
13. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
14. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
15. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank,

- and adjustable thermostat.
16. Support: Fixture carrier.
 17. Water-Cooler Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1]**.
 18. Capacities and Characteristics:
 - a. Cooled Water: **[5 gph (0.0053 L/s)][8 gph (0.0084 L/s)]<Insert value>**.
 - b. Ambient-Air Temperature: **90 deg F (32 deg C)**.
 - c. Inlet-Water Temperature: **80 deg F (27 deg C)**.
 - d. Cooled-Water Temperature: **50 deg F (10 deg C)**.
 - e. Cooled-Water Storage: **<Insert value>**.
 - f. Electrical Characteristics:
 - 1) Motor Horsepower: **[1/6][1/5][1/4][1/3]<Insert value>**.
 - 2) Volts: 120 V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60 Hz.
 - 5) Full-Load Amperes: **<Insert value> A**.
 - 6) Minimum Circuit Ampacity: **<Insert value> A**.
 - 7) Maximum Overcurrent Protection: **<Insert value> A**.

E. Water Coolers - Surface Wall Mounted, Vinyl-Covered Metal with Stainless Steel Top :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain surface wall-mounted, vinyl-covered metal water coolers with stainless steel top from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
 - d. ASHRAE 18.
 - e. UL 399.
 - f. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Type: **[Vandal resistant][and][freeze resistant]**.
6. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
7. Control: **[Push button][Push bar][Sensor]<Insert control>**.
8. Glass filler.

9. Bottle Filler: **[Sensor][Push-button]** activation[, with]**[20-second]<Insert value>[automatic shutoff timer]**: Fill rate is **[0.5 to 1.5 gpm (0.03155 to 0.09464 L/s)]<Insert value>**.
10. Drain: Grid with **NPS 1-1/4 (DN 32)** tailpiece.
11. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
12. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
13. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
14. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
15. Support: Fixture carrier.
16. Water-Cooler Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1]**.
17. Capacities and Characteristics:
 - a. Cooled Water: **[5 gph (0.0053 L/s)][8 gph (0.0084 L/s)]<Insert value>**.
 - b. Ambient-Air Temperature: **90 deg F (32 deg C)**.
 - c. Inlet-Water Temperature: **80 deg F (27 deg C)**.
 - d. Cooled-Water Temperature: **50 deg F (10 deg C)**.
 - e. Cooled-Water Storage: **<Insert value>**.
 - f. Electrical Characteristics:
 - 1) Motor Horsepower: **[1/6][1/5][1/4][1/3]<Insert value>**.
 - 2) Volts: 120 V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60 Hz.
 - 5) Full-Load Amperes: **<Insert value> A**.
 - 6) Minimum Circuit Ampacity: **<Insert value> A**.
 - 7) Maximum Overcurrent Protection: **<Insert value> A**.

F. Water Coolers - Inwall Frame/Plate, Wall Mounted, Stainless Steel :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **[Murdock Manufacturing; A Division of Morris Group International]**
 - d. **[Oasis International]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **[Murdock Manufacturing; A Division of Morris Group International]**

- d. **[Oasis International]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain inwall frame/plate, wall-mounted, stainless steel, water coolers from single source from single manufacturer.
 4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
 - d. ASHRAE 18.
 - e. UL 399.
 - f. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 5. Type: **[Vandal resistant][and][freeze resistant]**.
 6. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
 7. Control: **[Push button][Push bar][Sensor]<Insert control>**.
 8. Glass filler.
 9. Bottle Filler: **[Sensor][Push-button]** activation[, with]**[20-second]<Insert value>[automatic shutoff timer]**. Fill rate is **[0.5 to 1.5 gpm (0.03155 to 0.09464 L/s)]<Insert value>**.
 10. Drain: Grid with **NPS 1-1/4 (DN 32)** tailpiece.
 11. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
 12. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
 13. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
 14. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 15. Support: Provide manufacturer's support frame for attachment to substrate.
 16. Water-Cooler Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1][High/low - standard/accessible in accordance with ICC A117.1]**.
 17. Capacities and Characteristics:
 - a. Cooled Water: **[5 gph (0.0053 L/s)][8 gph (0.0084 L/s)]<Insert value>**.
 - b. Ambient-Air Temperature: **90 deg F (32 deg C)**.
 - c. Inlet-Water Temperature: **80 deg F (27 deg C)**.
 - d. Cooled-Water Temperature: **50 deg F (10 deg C)**.
 - e. Cooled-Water Storage: **<Insert value>**.
 - f. Electrical Characteristics:
 - 1) Motor Horsepower: **[1/6][1/5][1/4][1/3]<Insert value>**.
 - 2) Volts: 120 V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60 Hz.
 - 5) Full-Load Amperes: **<Insert value> A**.
 - 6) Minimum Circuit Ampacity: **<Insert value> A**.
 - 7) Maximum Overcurrent Protection: **<Insert value> A**.

G. Water Coolers - Semi-Recessed, Wall Mounted, Stainless Steel :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Halsey Taylor]**
 - b. **[Oasis International]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Halsey Taylor]**
 - b. **[Oasis International]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain semi-recessed, wall-mounted, stainless steel, water coolers from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
 - d. ASHRAE 18.
 - e. UL 399.
 - f. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. **[Type: Vandal resistant.]**
6. Bubbler: One, with adjustable stream regulator, located on deck.
7. Control: **[Push button][Push bar]<Insert control>**.
8. Drain: Grid with **NPS 1-1/4 (DN 32)** tailpiece.
9. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
10. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
11. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
12. Cooling System: Electric, with **[precooler]**,hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
13. Support: Provide manufacturer's support frame attachment to substrate.
14. Water-Cooler Mounting Height: **[Standard][Juvenile]**.
15. Capacities and Characteristics:
 - a. Cooled Water: **[8 gph (0.0084 L/s)][12 gph (0.0126 L/s)]<Insert value>**.
 - b. Ambient-Air Temperature: **90 deg F (32 deg C)**.
 - c. Inlet-Water Temperature: **80 deg F (27 deg C)**.
 - d. Cooled-Water Temperature: **50 deg F (10 deg C)**.
 - e. Cooled-Water Storage: **<Insert value>**.
 - f. Electrical Characteristics:

- 1) Motor Horsepower: [1/6][1/5]<Insert value>.
- 2) Volts: 120 V ac.
- 3) Phase: Single.
- 4) Hertz: 60 Hz.
- 5) Full-Load Amperes: <Insert value> A.
- 6) Minimum Circuit Ampacity: <Insert value> A.
- 7) Maximum Overcurrent Protection: <Insert value> A.

H. Water Coolers - Semi-Recessed, Wall Mounted, Powder-Coated Metal :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Oasis International]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Oasis International]
 - b. <Insert manufacturer's name>
3. Source Limitations: Obtain semi-recessed, wall-mounted, powder-coated-metal, water coolers from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASHRAE 18.
 - d. UL 399.
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. [Type: Vandal resistant].
6. Bubbler: One, with adjustable stream regulator, located on deck.
7. Control: [Push button][Push bar]<Insert control>.
8. Drain: Grid with NPS 1-1/4 (DN 32) tailpiece.
9. Supply: NPS 3/8 (DN 10) with shutoff valve.
10. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 (DN 32) brass P-trap.
11. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
12. Cooling System: Electric, with [precooler,]hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
13. Support: Provide manufacturer's support frame attachment to substrate.
14. Water-Cooler Mounting Height: [Standard][Juvenile].
15. Capacities and Characteristics:

- a. Cooled Water: [8 gph (0.0084 L/s)][12 gph (0.0126 L/s)]<Insert value>.
- b. Ambient-Air Temperature: 90 deg F (32 deg C).
- c. Inlet-Water Temperature: 80 deg F (27 deg C).
- d. Cooled-Water Temperature: 50 deg F (10 deg C).
- e. Cooled-Water Storage: <Insert value>.
- f. Electrical Characteristics:

- 1) Motor Horsepower: [1/6][1/5]<Insert value>.
- 2) Volts: 120 V ac.
- 3) Phase: Single.
- 4) Hertz: 60 Hz.
- 5) Full-Load Amperes: <Insert value> A.
- 6) Minimum Circuit Ampacity: <Insert value> A.
- 7) Maximum Overcurrent Protection: <Insert value> A.

I. Water Coolers - Recessed, Wall Mounted, Stainless Steel :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Elkay]
 - b. [Halsey Taylor]
 - c. [Murdock Manufacturing; A Division of Morris Group International]
 - d. [Oasis International]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Elkay]
 - b. [Halsey Taylor]
 - c. [Murdock Manufacturing; A Division of Morris Group International]
 - d. [Oasis International]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain recessed, wall-mounted, stainless steel, water coolers from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
 - d. ASHRAE 18.
 - e. UL 399.
 - f. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. [Type: Vandal resistant.]
6. bubbler: One, with adjustable stream regulator, located on deck.
7. Control: [Push button][Push bar]<Insert control>.
8. Glass filler.
9. Drain: Grid with NPS 1-1/4 (DN 32) tailpiece.

10. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
11. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
12. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
13. Cooling System: Electric, with **[precooler]**, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
14. Ventilation Grille: Stainless steel, located **[above][below]** water cooler.
15. Support: Provide manufacturer's support frame attachment to substrate.
16. Water-Cooler Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
17. Capacities and Characteristics:
 - a. Cooled Water: **[8 gph (0.0084 L/s)][12 gph (0.0126 L/s)]<Insert value>**.
 - b. Ambient-Air Temperature: **90 deg F (32 deg C)**.
 - c. Inlet-Water Temperature: **80 deg F (27 deg C)**.
 - d. Cooled-Water Temperature: **50 deg F (10 deg C)**.
 - e. Cooled-Water Storage: **<Insert value>**.
 - f. Electrical Characteristics:
 - 1) Motor Horsepower: **[1/6][1/5]<Insert value>**.
 - 2) Volts: 120 V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60 Hz.
 - 5) Full-Load Amperes: **<Insert value> A**.
 - 6) Minimum Circuit Ampacity: **<Insert value> A**.
 - 7) Maximum Overcurrent Protection: **<Insert value> A**.

2.4 BOTTLE FILLING STATIONS

A. Bottle Filling Station - Surface Wall Mounted, ABS/Stainless Steel Combination :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Haws Corporation]**
 - b. **[Murdock Manufacturing; A Division of Morris Group International]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Haws Corporation]**
 - b. **[Murdock Manufacturing; A Division of Morris Group International]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain surface wall-mounted, ABS/stainless steel combination, bottle filling

- stations from single source from single manufacturer.
 4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 5. Type: **[Vandal resistant][and][freeze resistant]**.
 6. Cabinet: ABS/stainless steel combination.
 7. Bottle Filler: **[Sensor][Push-button]** activation[, with]**[20-second]<Insert value>[automatic shutoff timer]**. Fill rate is **[0.5 to 1.5 gpm (0.03155 to 0.09464 L/s)]<Insert value>**.
 8. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
 9. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
 10. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
 11. Filter: One or more water filters complying with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
 12. Support: Provide manufacturer's mounting plate.
 13. Bottle Filling Station Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
 14. Electrical Characteristics:
 - a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - b. Volts: 120 V ac.
 - c. Phase: Single.
 - d. Hertz: 60 Hz.
- B. Bottle Filling Station - Surface Wall Mounted, Powder-Coated Metal :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Most Dependable Fountains, Inc.]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Most Dependable Fountains, Inc.]**
 - b. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain surface wall-mounted, powder-coated-metal, bottle filling stations from single source from single manufacturer.
 4. Standards:
 - a. NSF 61.
 - b. NSF 372.

5. Type: **[Vandal resistant][and][freeze resistant]**.
6. Cabinet: Powder-coated metal.
7. Finish Color: **<Insert color>**.
8. Bottle Filler: Push-button activation.
9. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
10. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
11. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
12. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
13. Support: Provide manufacturer's mounting plate.
14. Bottle Filling Station Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.

C. Bottle Filling Station - Surface Wall Mounted, Stainless Steel :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **[Most Dependable Fountains, Inc.]**
 - d. **[Murdock Manufacturing; A Division of Morris Group International]**
 - e. **[Oasis International]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **[Most Dependable Fountains, Inc.]**
 - d. **[Murdock Manufacturing; A Division of Morris Group International]**
 - e. **[Oasis International]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain surface wall-mounted, stainless steel, bottle filling stations from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
5. Type: **[Vandal resistant][and][freeze resistant]**.
6. Cabinet: Stainless steel.
7. Bottle Filler: **[Sensor][Push-button]** activation[, with]**[20-second]<Insert value>****[automatic shutoff timer]**. Fill rate is **[0.5 to 1.5 gpm (0.03155 to 0.09464 L/s)]<Insert value>**.
8. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.

9. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
 10. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
 11. Cooling System: Electric, with **[precooler,]**hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - a. Standards:
 - 1) ASHRAE 18.
 - 2) UL 399.
 - 3) Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 12. Ventilation Grille: Stainless steel, located **[above][below]** bottle filler.
 13. Cooling System Capacities and Characteristics:
 - a. Cooled Water: **[8 gph (0.0084 L/s)][12 gph (0.0126 L/s)]<Insert value>.**
 - b. Ambient-Air Temperature: **90 deg F (32 deg C).**
 - c. Inlet-Water Temperature: **80 deg F (27 deg C.)**
 - d. Cooled-Water Temperature: **50 deg F (10 deg C).**
 - e. Cooled-Water Storage: **<Insert value>.**
 - f. Electrical Characteristics:
 - 1) Motor Horsepower: **[1/6][1/5]<Insert value>.**
 - 2) Volts: 120 V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60 Hz.
 - 5) Full-Load Amperes: **<Insert value> A.**
 - 6) Minimum Circuit Ampacity: **<Insert value> A.**
 - 7) Maximum Overcurrent Protection: **<Insert value> A.**
 14. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
 15. Support: Provide manufacturer's mounting plate.
 16. Bottle Filling Station Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1].**
 17. Electrical Characteristics:
 - a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - b. Volts: 120 V ac.
 - c. Phase: Single.
 - d. Hertz: 60 Hz.
- D. Bottle Filling Station - Recessed, Wall Mounted, ABS/Stainless Steel Combination :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [Haws Corporation]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Haws Corporation]
 - b. <Insert manufacturer's name>
 3. Source Limitations: Obtain recessed, wall-mounted, ABS/stainless steel combination, bottle filling stations from single source from single manufacturer.
 4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4
 5. Type: [Vandal resistant][and][freeze resistant].
 6. Cabinet: ABS/stainless steel combination.
 7. Bottle Filler: Sensor activation[, with][20-second]<Insert value>[automatic shutoff timer]. Fill rate is [0.5 to 1.5 gpm (0.03155 to 0.09464 L/s)]<Insert value>.
 8. Drain: Grid type with NPS 1-1/4 (DN 32) tailpiece.
 9. Supply: NPS 3/8 (DN 10) with shutoff valve.
 10. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 (DN 32) brass P-trap.
 11. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
 12. Support: Provide manufacturer's frame attached to substrate.
 13. Bottle Filling Station Mounting Height: [Standard][Juvenile][Accessible in accordance with ICC A117.1].
 14. Electrical Characteristics:
 - a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - b. Volts: 120 V ac.
 - c. Phase: Single.
 - d. Hertz: 60 Hz.
- E. Bottle Filling Station - Recessed, Wall Mounted, Powder-Coated Metal :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Elkay]
 - b. [Most Dependable Fountains, Inc.]
 - c. [Murdock Manufacturing; A Division of Morris Group International]
 - d. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **[Most Dependable Fountains, Inc.]**
 - c. **[Murdock Manufacturing; A Division of Morris Group International]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain recessed, wall-mounted, powder-coated-metal, bottle filling stations from single source from single manufacturer.
 4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 5. Type: **[Vandal resistant][and][freeze resistant]**.
 6. Cabinet: Powder-coated metal.
 7. Finish Color: **<Insert color>**.
 8. Bottle Filler: **[Sensor][Push-button]** activation[, with][**20-second**]**<Insert value>****[automatic shutoff timer]**. Fill rate is **[0.5 to 1.5 gpm (0.03155 to 0.09464 L/s)]<Insert value>**.
 9. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
 10. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
 11. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
 12. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
 13. Support: Provide manufacturer's frame attached to substrate.
 14. Bottle Filling Station Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
 15. Electrical Characteristics:
 - a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - b. Volts: 120 V ac.
 - c. Phase: Single.
 - d. Hertz: 60 Hz.
- F. Bottle Filling Station - Recessed, Wall Mounted, Stainless Steel :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **[Most Dependable Fountains, Inc.]**
 - d. **[Murdock Manufacturing; A Division of Morris Group International]**
 - e. **[Oasis International]**
 - f. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **[Most Dependable Fountains, Inc.]**
 - d. **[Murdock Manufacturing; A Division of Morris Group International]**
 - e. **[Oasis International]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain recessed, wall-mounted, stainless steel, bottle filling stations from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.
5. Type: **[Vandal resistant][and][freeze resistant]**.
6. Cabinet: Stainless steel.
7. Bottle Filler: **[Sensor][Push-button]** activation[, with][**20-second**]**<Insert value>****[automatic shutoff timer]**. Fill rate is **[0.5 to 1.5 gpm (0.03155 to 0.09464 L/s)]<Insert value>**.
8. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
9. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
10. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
11. Cooling System: Electric, with **[precooler]**,hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - a. Standards:
 - 1) ASHRAE 18.
 - 2) UL 399.
 - 3) Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
12. Ventilation Grille: Stainless steel, located **[above][below]** bottle filler.
13. Cooling System Capacities and Characteristics:
 - a. Cooled Water: **[8 gph (0.0084 L/s)][12 gph (0.0126 L/s)]<Insert value>**.
 - b. Ambient-Air Temperature: **90 deg F (32 deg C)**.
 - c. Inlet-Water Temperature: **80 deg F (27 deg C)**.
 - d. Cooled-Water Temperature: **50 deg F (10 deg C)**.
 - e. Cooled-Water Storage: **<Insert value>**.
 - f. Electrical Characteristics:
 - 1) Motor Horsepower: **[1/6][1/5]<Insert value>**.
 - 2) Volts: 120 V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60 Hz.
 - 5) Full-Load Amperes: **<Insert value> A**.
 - 6) Minimum Circuit Ampacity: **<Insert value> A**.
 - 7) Maximum Overcurrent Protection: **<Insert value> A**.

14. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
15. Support: Provide manufacturer's frame attached to substrate.
16. Bottle Filling Station Mounting Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
17. Electrical Characteristics:
 - a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - b. Volts: 120 V ac.
 - c. Phase: Single.
 - d. Hertz: 60 Hz.

G. Bottle Filling Station - Pedestal, Powder-Coated Metal :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **[Haws Corporation]**
 - d. **[Most Dependable Fountains, Inc.]**
 - e. **[Murdock Manufacturing; A Division of Morris Group International]**
 - f. **[Stern-Williams Products, LLC.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **[Halsey Taylor]**
 - c. **[Haws Corporation]**
 - d. **[Most Dependable Fountains, Inc.]**
 - e. **[Murdock Manufacturing; A Division of Morris Group International]**
 - f. **[Stern-Williams Products, LLC.]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain pedestal, powder-coated-metal, bottle filling stations from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
5. Type: **[Vandal resistant][and][freeze resistant]**.
6. Pedestal: **[Rectangular][Round]<Insert shape>**.
7. Finish Color: **<Insert color>**

8. Bottle Filler: **[Sensor][Push-button]** activation[, with]**[20-second]<Insert value>[automatic shutoff timer]**. Fill rate is **[0.5 to 1.5 gpm (0.03155 to 0.09464 L/s)]<Insert value>**.
9. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
10. Access to Internal Components: Panel in pedestal.
11. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
12. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
13. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
14. Bottle Filling Station Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
15. Freeze-Resistant Supply Fittings: Underground freeze-resistant shutoff and flow-control valve assembly.
16. Bury Depth, Grade to Valve Components: **[36 inches (915 mm)][48 inches (1220 mm)][60 inches (1525 mm)]<Insert dimension>**.
17. Electrical Characteristics:
 - a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - b. Volts: 120 V ac.
 - c. Phase: Single.
 - d. Hertz: 60 Hz.

H. Bottle Filling Station - Pedestal, Stainless Steel :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Haws Corporation]**
 - b. **[Most Dependable Fountains, Inc.]**
 - c. **[Murdock Manufacturing; A Division of Morris Group International]**
 - d. **[Stern-Williams Products, LLC.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Haws Corporation]**
 - b. **[Most Dependable Fountains, Inc.]**
 - c. **[Murdock Manufacturing; A Division of Morris Group International]**
 - d. **[Stern-Williams Products, LLC.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain pedestal, stainless steel, bottle filling stations from single source from single manufacturer.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. ASME A112.19.3/CSA B45.4.

5. Type: **[Vandal resistant][and][freeze resistant]**.
6. Pedestal: **[Rectangular][Round]<Insert shape>**.
7. Bottle Filler: **[Sensor][Push-button]** activation[, with][**20-second**]**<Insert value>****[automatic shutoff timer]**. Fill rate is **[0.5 to 1.5 gpm (0.03155 to 0.09464 L/s)]<Insert value>**.
8. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
9. Access to Internal Components: Panel in pedestal.
10. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
11. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
12. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** brass P-trap.
13. Bottle Filling Station Height: **[Standard][Juvenile][Accessible in accordance with ICC A117.1]**.
14. Freeze-Resistant Supply Fittings: Underground freeze-resistant shutoff and flow-control valve assembly.
15. Bury Depth, Grade to Valve Components: **[36 inches (915 mm)][48 inches (1220 mm)][60 inches (1525 mm)]<Insert dimension>**.
16. Electrical Characteristics:
 - a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - b. Volts: 120 V ac.
 - c. Phase: Single.
 - d. Hertz: 60 Hz.

2.5 REMOTE WATER COOLERS

A. Remote Water Coolers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elkay]**
 - b. **[Filtrine Manufacturing Company]**
 - c. **[Halsey Taylor]**
 - d. **[Haws Corporation]**
 - e. **[Oasis International]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elkay]**
 - b. **[Filtrine Manufacturing Company]**
 - c. **[Halsey Taylor]**
 - d. **[Haws Corporation]**
 - e. **[Oasis International]**
 - f. **<Insert manufacturer's name>**

3. Description: Remote water-cooling chiller unit serving cooled water to drinking water fountains or bottle filling stations.
4. Standards:
 - a. NSF 61.
 - b. NSF 372.
 - c. UL 399.
 - d. ASHRAE 18.
 - e. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Refrigerant: **[R134a][or][R513A]<Insert refrigerant type>**.
6. Chassis: Galvanized or corrosion-resistant coated steel.
7. Chiller: Hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, and refrigerant.
8. Storage Tank: **[0.5 gal. (1.9 L)][4 gal. (15.1 L)]<Insert value>**, stainless steel.
9. Controls: Adjustable thermostat.
10. Ventilation Grille: Stainless steel, **<Insert size>**.
11. Filter: One or more water filters with capacity sized for unit peak flow rate.
 - a. Standards:
 - 1) NSF 42.
 - 2) NSF 53.
12. Capacities and Characteristics:
 - a. Cooled Water: **[5 gph (0.0053 L/s)][8 gph (0.0084 L/s)][14 gph (0.0147 L/s)]<Insert value>**.
 - b. Ambient-Air Temperature: **90 deg F (32 deg C)**.
 - c. Inlet-Water Temperature: **80 deg F (27 deg C)**.
 - d. Cooled-Water Temperature: **50 deg F (10 deg C)**.
 - e. Cooled-Water Storage: **<Insert gal. (L)>**.
 - f. Electrical Characteristics:
 - 1) Motor Horsepower: **[1/5][1/4][1/3]<Insert value>**.
 - 2) Volts: 120 V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60.
 - 5) Full-Load Amperes: **<Insert value>**.
 - 6) Minimum Circuit Ampacity: **<Insert value>**.
 - 7) Maximum Overcurrent Protection: **<Insert amperage>**.

2.6 FIXTURE CARRIERS

A. Fixture Carriers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Jay R. Smith Mfg Co; a division of Morris Group International]**
 - b. **[Josam Company]**
 - c. **[MIFAB, Inc]**

- d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Jay R. Smith Mfg Co; a division of Morris Group International]
 - b. [Josam Company]
 - c. [MIFAB, Inc]
 - d. [Wade; a subsidiary of McWane Inc.]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
3. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.
- B. Examine walls and floors for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install fixtures level and plumb in accordance with roughing-in drawings. For fixtures indicated for juveniles, install at height required by authorities having jurisdiction.
 - B. Set pedestal drinking fountains and bottle filling stations on flat surface in accordance with manufacturer's written installation instructions.
 - C. Set freestanding water coolers on floor.
 - D. Install recessed drinking fountains and bottle filling stations secured to wood blocking in wall construction.
 - E. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
 - F. Install mounting frames, affixed to building construction, and attach recessed water coolers and bottle filling stations to mounting frames.
 - G. Set remote water coolers on floor unless otherwise indicated.
1. Comply with requirements for vibration isolation and seismic-control devices specified in Section

- 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
2. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

- H. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball[**or gate**] valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- I. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- J. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
- K. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 PIPING CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Install ball[**or gate**] shutoff valve on water supply to each fixture. [**Install ball or gate valves with valved bypass on water connections to remote water coolers**]. [**Install valve upstream from filter for drinking fountain, water cooler, and bottle filling station.**] Comply with valve requirements specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplates to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplates to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 ADJUSTING

- A. Adjust fixture flow regulators for proper flow and stream height.
- B. Adjust water cooler temperature settings.
- C. Adjust electronic-sensor settings.

3.6 CLEANING

- A. After installing fixtures, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean fixtures, on completion of installation, in accordance with manufacturer's written instructions.
- C. Provide protective covering for installed fixtures.
- D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 47 00 00



Task	Specification	Specification Description
22 47 13 00	22 47 00 00	Drinking Fountains And Water Coolers
22 47 16 00	22 45 00 00	Emergency Plumbing Fixtures
22 47 16 00	22 47 00 00	Drinking Fountains And Water Coolers
22 47 19 00	22 47 00 00	Drinking Fountains And Water Coolers
22 47 23 00	22 47 00 00	Drinking Fountains And Water Coolers
22 47 26 00	22 47 00 00	Drinking Fountains And Water Coolers



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 63 13 00 - GAS PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Shape-memory-metal couplings.
3. Corrugated medical tubing (CMT) - copper.
4. Joining materials.
5. Zone valve box assemblies.
6. Ball valves.
7. Check valves.
8. Emergency oxygen connections.
9. Gas safety valves.
10. Pressure regulators.
11. Gas-service connections.
12. Patient-service consoles.
13. Nitrogen pressure-control panels.
14. Ceiling columns.
15. Gas manifolds.
16. Simplex specialty gas manifolds.
17. Duplex specialty gas manifolds.
18. Bulk medical gas storage tanks.
19. Gas cylinder storage racks.

B. Owner-Furnished Material:

1. Patient-service consoles.
2. Ceiling columns.
3. Gas manifolds.
4. Bulk medical gas storage tanks.
5. **<Insert product>**.
6. Owner will furnish gases for **[medical][laboratory]** gas concentration testing specified in this Section.

C. Related Requirements:

1. Section 018123 "Facility Seismic and Wind Criteria" for building seismic criteria.
2. Section 115313 "Laboratory Fume Hoods" for gas outlets in laboratory fume hoods.
3. Section 123553.13 "Metal Laboratory Casework" for gas outlets in laboratory fume hoods.
4. Section 123553.16 "Plastic-Laminate-Clad Laboratory Casework" for gas outlets in plastic-laminate-clad laboratory casework.
5. Section 123553.19 "Wood Laboratory Casework" for gas outlets in laboratory casework.
6. Section 123570 "Healthcare Casework" for gas outlets in medical casework.
7. Section 220963 "Medical Gas Alarms" for combined medical air, vacuum, and gas alarms.

1.2 DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.

- B. D.I.S.S.: Diameter-Index Safety System.
- C. Medical gas piping systems include medical carbon dioxide, medical helium, medical nitrogen, medical nitrous oxide, and medical oxygen **<Insert other medical and combination gases>** for healthcare facility patient care.
- D. Laboratory gas piping systems include carbon dioxide, helium, nitrogen, nitrous oxide, and oxygen **<Insert other medical and combination gases>** for laboratories.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[Installer][and][testing agency]**.
- B. Seismic Qualification Data: Certificates, for **[gas manifolds][and][bulk gas storage tanks]**, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Material Certificates: Signed by Installer, certifying that medical gas piping materials comply with requirements in NFPA 99 for positive-pressure medical gas systems.
- D. Brazing certificates.
- E. Field quality control reports.
- F. Source Quality Control Reports:
 - 1. Certificates of Shop Inspection and Data Report for Bulk Gas Storage Tanks: As required by ASME Boiler and Pressure Vessel Code.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For **[medical][and][specialty]** gas piping specialties to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Quick-Coupler Service Connections: Furnish complete noninterchangeable medical gas-pressure outlets and suction inlets.
 - a. Medical Carbon Dioxide: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - b. Medical Nitrous Oxide: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - c. Medical Oxygen: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - d. **<Insert medical gas>**. Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - e. Laboratory Carbon Dioxide: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - f. Laboratory Nitrous Oxide: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - g. Laboratory Oxygen: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - h. **<Insert laboratory gas>**. Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
2. D.I.S.S. Service Connections: Furnish complete medical gas pressure outlets and suction inlets complying with CGA V-5.
 - a. Medical Carbon Dioxide D.I.S.S. No. 1080: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - b. Medical Helium D.I.S.S. No. 1060: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - c. Medical Nitrogen D.I.S.S. No. 1120: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - d. Medical Nitrous Oxide D.I.S.S. No. 1040: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - e. Medical Oxygen D.I.S.S. No. 1240: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - f. **<Insert medical gas and D.I.S.S. No.>**. Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - g. Laboratory Carbon Dioxide D.I.S.S. No. 1080: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - h. Laboratory Helium D.I.S.S. No. 1060: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - i. Laboratory Nitrogen D.I.S.S. No. 1120: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - j. Laboratory Nitrous Oxide D.I.S.S. No. 1040: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - k. Laboratory Oxygen D.I.S.S. No. 1240: Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.
 - l. **<Insert laboratory gas and D.I.S.S. No.>**. Equal to **<Insert number>** percent of quantity installed, but no fewer than **<Insert number>** units.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Medical Gas Piping Systems for Healthcare Facilities: In accordance with ASSE Standard #6010[**and NFPA 99**] for medical-gas-system installers.
2. Bulk Medical Gas Systems for Healthcare Facilities: In accordance with ASSE Standard #6015[

- and **NFPA 99**] for bulk-medical-gas-system installers.
- 3. Shape-Memory-Metal Coupling Joints: An authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the medical gas piping testing indicated, that is[**a member of the Medical Gas Professional Healthcare Organization or is**] an NRTL, and that is acceptable to authorities having jurisdiction.
 - 1. Qualify testing personnel in accordance with ASSE Standard #6020[**and NFPA 99**] for medical-gas-system inspectors and ASSE Standard #6030 for medical-gas-system verifiers.
- C. Brazing: Qualify processes and operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications," or AWS B2.2/B2.2M.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. **[Medical][and][laboratory]** carbon dioxide operating at **[50 to 55 psig (345 to 380 kPa)]<Insert values>**.
- B. **[Medical][and][laboratory]** helium operating at **[50 to 55 psig (345 to 380 kPa)]<Insert values>**.
- C. **[Medical][and][laboratory]** nitrogen operating at **[160 to 185 psig (1100 to 1275 kPa)][higher than 200 psig (1380 kPa)]<Insert values>**.
- D. **[Medical][and][laboratory]** nitrous oxide operating at **[50 to 55 psig (345 to 380 kPa)]<Insert values>**.
- E. **[Medical][and][laboratory]** oxygen operating at **[50 to 55 psig (345 to 380 kPa)]<Insert values>**.
- F. Specialty **<Insert designation>** operating at **[50 to 55 psig (345 to 380 kPa)]<Insert values>**.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: **[Gas manifolds][and][bulk gas storage tanks]** are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the **[gas manifolds][and][bulk gas storage tanks]** will remain in place without separation of any parts when subjected to the seismic forces specified[**and the manifolds and tanks will be fully operational after the seismic event**]."
 - 2. Component Importance Factor is **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- B. Comply with NFPA 55
- C. Comply with NFPA 99.

2.3 PIPES, TUBES, AND FITTINGS

- A. For all **[medical][and][laboratory]** gases, all positive-pressure **[medical][and][laboratory]** gas piping, tubing, and fittings are to have been manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.
1. Each length of tubing is to be delivered plugged or capped by the manufacturer and kept sealed until prepared for installation.
 2. Fittings and other components are to be delivered manufacturer sealed and labeled, and kept sealed until prepared for installation.
- B. Copper Medical and Laboratory Gas Tube: ASTM B819, **[Type K][and][Type L]**, seamless, drawn temper. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and blue for Type L tube.
- C. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type.
- D. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.
- E. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, **1/8-inch (3.2-mm)** maximum thickness, full-face type.
 2. Flange Bolts and Nuts: ASME B18.2.1 carbon steel.
- F. Shape-Memory-Metal Couplings:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Aerofit, Inc]**
 - b. **[CAMERON; A Schlumber Co.]**
 - c. **[Motion Industries]**
 - d. **[Smart Tap; Smart Technology, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aerofit, Inc]**
 - b. **[CAMERON; A Schlumber Co.]**
 - c. **[Motion Industries]**
 - d. **[Smart Tap; Smart Technology, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Description: Cryogenic compression fitting made of nickel-titanium, shape-memory alloy.
- G. Corrugated Medical Tubing (CMT) - Copper:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[MediTrac; OmegaFlex Inc.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[MediTrac; OmegaFlex Inc.]**
 - b. **<Insert manufacturer's name>**
3. Description: Corrugated medical tubing system including corrugated copper-alloy tubing and brass fittings equipped for direct connection to medical gas piping system components.
4. Standards:
 - a. UL Through-Penetration Ratings: W-L-1604 and C-AJ-1751.
 - b. UL Listed: MH64301 UL 1365.
 - c. Seismically qualified in accordance with ICC-ES AC156; testing protocol in accordance with ICC-ESR-4565.
 - d. NFPA 99.
5. Quality Certification: Certified to ISO 9001 and 13485:2016 Medical Device Standard.
6. Tubing: ASTM B103/B103M, copper alloy UNS C51000, seamless, corrugated flexible medical tubing.
7. Jacket: Low-density polyethylene.
8. Jacket Flame Spread/Smoke Developed Rating: 25/50, in accordance with ASTM E84.
9. Maximum Operating Pressure, Continuous Use: **185 psig (1275 kPa)**.
10. Test Pressure: **647.4 psig (4464 kPa)**, maximum.
11. Safety Factor: 3.5 times maximum operating pressure, in accordance with NFPA 99.
12. Maximum Operating Temperature, Continuous Use: **250 deg F (121 deg C)**.
13. Maximum Exposure Temperature: **1000 deg F (538 deg C)**, in accordance with NFPA 99.
14. Minimum Bend Radius:
 - a. **6 inches for 1/2-inch tubing (180 mm for 15-mm tubing).**
 - b. **8 inches for 3/4-inch tubing (264 mm for 22-mm tubing).**
 - c. **10 inches for 1-inch tubing (336 mm for 28-mm tubing).**
 - d. **24 inches for 1-1/2-inch tubing (600 mm for 50-mm tubing).**
15. Fitting: Brass axial swage fittings, NFPA 99 compliant, and cleaned in accordance with CGA G-4.1, including the following components:
 - a. Adaptor Material: CA360 brass.
 - b. Anti-Tamper Sleeve Material: 300 series stainless steel.
 - c. Non-Removable Threaded Axial Swaging Tool Material: CA360 brass.
 - d. Split Ring Material: Brass, stainless steel.
 - e. Jacket Lock Material: CA360 brass.
 - f. Rear Swage Sleeve Material: CA360 brass.
 - g. Treaded Driver Material: 300 series stainless steel.

2.4 JOINING MATERIALS

- A. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys.
- B. Threaded-Joint Tape: PTFE.

2.5 VALVES

- A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged in accordance with CGA G-4.1 for oxygen service.
- B. Zone Valve Box Assemblies: Box with medical gas valves, tube extensions, and gauges.
 - 1. Steel Zone Valve Box with Aluminum Cover:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Amico Corporation]**
 - 2) **[BeaconMedaes]**
 - 3) **[CONCOA]**
 - 4) **[Ohio Medical Corporation]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Amico Corporation]**
 - 2) **[BeaconMedaes]**
 - 3) **[CONCOA]**
 - 4) **[Ohio Medical Corporation]**
 - 5) **<Insert manufacturer's name>**
 - c. Description: Formed-steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gauges and in sizes required to permit manual operation of valves.**[Medical air and medical vacuum tubing, valves, and gauges may be incorporated in zone valve boxes for medical gases.]**
 - 1) Interior Finish: Factory-applied white enamel.
 - 2) Cover Plate: Aluminum with frangible or removable windows.
 - 3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, in accordance with NFPA 99.
 - d. Positive-Pressure Medical Gas Valves, for All Medical Gas Types:
 - 1) Manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.
 - 2) Delivered sealed and labeled and kept sealed until prepared for installation.
 - 2. Steel Zone Valve Box with Stainless Steel Cover:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Amico Corporation]**
 - 2) **[BeaconMedaes]**

- 3) [Ohio Medical Corporation]
- 4) [Tri-Tech Medical]
- 5) <Insert manufacturer's name>

b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) [Amico Corporation]
- 2) [BeaconMedaes]
- 3) [Ohio Medical Corporation]
- 4) [Tri-Tech Medical]
- 5) <Insert manufacturer's name>

c. Description: Formed-steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gauges and in sizes required to permit manual operation of valves. [**Medical air and medical vacuum tubing, valves, and gauges may be incorporated in zone valve boxes for medical gases.**]

- 1) Interior Finish: Factory-applied white enamel.
- 2) Cover Plate: Stainless steel with frangible or removable windows.
- 3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, in accordance with NFPA 99.

d. Positive-Pressure Medical Gas Valves, for All Medical Gas Types:

- 1) Manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.
- 2) Delivered sealed and labeled and kept sealed until prepared for installation.

C. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Amico Corporation]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [BeaconMedaes]
- d. [Marwin Valve; Richards Industries]
- e. [NIBCO INC.]
- f. [Ohio Medical Corporation]
- g. [Tri-Tech Medical]
- h. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Amico Corporation]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [BeaconMedaes]
- d. [Marwin Valve; Richards Industries]

- e. [NIBCO INC.]
 - f. [Ohio Medical Corporation]
 - g. [Tri-Tech Medical]
 - h. <Insert manufacturer's name>
- 3. Standard: MSS SP-110.
 - 4. Description: Three-piece body, brass or bronze.
 - 5. Pressure Rating: **300 psig (2070 kPa)** minimum.
 - 6. Ball: Full-port, chrome-plated brass.
 - 7. Seats: PTFE or TFE.
 - 8. Handle: Lever[**type with locking device**].
 - 9. Stem: Blowout proof with PTFE or TFE seal.
 - 10. Ends: **[Manufacturer-installed ASTM B819, copper-tube extensions][and][manufacturer-installed ASTM B819, copper-tube extensions with pressure gauge on one copper-tube extension]**.
 - 11. Positive-Pressure Medical Gas Valves, for All Medical Gas Types:
 - a. Manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.
 - b. Delivered sealed and labeled and kept sealed until prepared for installation.

D. Check Valves:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Amico Corporation]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [BeaconMedaes]
 - d. [Marwin Valve; Richards Industries]
 - e. [NIBCO INC.]
 - f. [Ohio Medical Corporation]
 - g. [Tri-Tech Medical]
 - h. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert **manufacturer's name; product name or designation**> or comparable product by one of the following:
 - a. [Amico Corporation]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [BeaconMedaes]
 - d. [Marwin Valve; Richards Industries]
 - e. [NIBCO INC.]
 - f. [Ohio Medical Corporation]
 - g. [Tri-Tech Medical]
 - h. <Insert manufacturer's name>
- 3. Description: In-line pattern, bronze.
- 4. Pressure Rating: **300 psig (2070 kPa)** minimum.
- 5. Operation: Spring loaded.
- 6. Ends: Manufacturer-installed ASTM B819, copper-tube extensions.
- 7. Positive-Pressure Medical Gas Valves, for All Gas Types:

- a. Manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.
 - b. Delivered sealed and labeled and kept sealed until prepared for installation.
- E. Emergency Oxygen Connections: Low-pressure oxygen inlet assembly for connection to building oxygen piping systems.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Amico Corporation]**
 - b. **[BeaconMedaes]**
 - c. **[Ohio Medical Corporation]**
 - d. **[Tri-Tech Medical]**
 - e. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Amico Corporation]**
 - b. **[BeaconMedaes]**
 - c. **[Ohio Medical Corporation]**
 - d. **[Tri-Tech Medical]**
 - e. **<Insert manufacturer's name>**
 - 3. Enclosure: Weatherproof hinged locking cover with caption similar to "Emergency Low-Pressure Gaseous Oxygen Inlet."
 - 4. Inlet: Manufacturer-installed, **NPS 1 or NPS 1-1/4 (DN 25 or DN 32)**, ASTM B819, copper tubing with **NPS 1 (DN 25)** minimum ball valve.
 - 5. Safety Valve: Bronze-body pressure-relief valve set at **75 or 80 psig (520 or 550 kPa)**.
 - 6. Instrumentation: Pressure gauge.
 - 7. Positive-Pressure Medical Gas Valves, for All Medical Gas Types:
 - a. Manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.
 - b. Delivered sealed and labeled and kept sealed until prepared for installation.
- F. Gas Safety Valves:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Amico Corporation]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[CEODEUX Meditec]**
 - d. **[UCSF Health Environment of Care]**
 - e. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. **[Amico Corporation]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[CEODEUX Meditec]**
 - d. **[UCSF Health Environment of Care]**
 - e. **<Insert manufacturer's name>**
3. Bronze body.
 4. ASME-construction, poppet, pressure-relief type.
 5. Settings to match system requirements.
 6. Positive-Pressure Medical Gas Valves, for All Gas Types:
 - a. Manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.
 - b. Delivered sealed and labeled and kept sealed until prepared for installation.
- G. Pressure Regulators:
1. **[Bronze][Stainless steel]** body and trim.
 2. Spring-loaded, diaphragm-operated, relieving type.
 3. Manual pressure-setting adjustment.
 4. Rated for **[250-psig (1725-kPa)]<Insert value>** minimum inlet pressure.
 5. Capable of controlling delivered gas pressure within **0.5 psig for each 10-psig (5.0 kPa for each 100-kPa)** inlet pressure.
 6. Positive-Pressure Medical Gas Valves, for All Gas Types:
 - a. Valves are to be manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.
 - b. Valves are to be delivered sealed and labeled and kept sealed until prepared for installation.

2.6 GAS-SERVICE CONNECTIONS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Amico Corporation]**
 2. **[BeaconMedaes]**
 3. **[Ohio Medical Corporation]**
 4. **[Tri-Tech Medical]**
 5. **[Western Enterprises]**
 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Amico Corporation]**
 2. **[BeaconMedaes]**
 3. **[Ohio Medical Corporation]**
 4. **[Tri-Tech Medical]**
 5. **[Western Enterprises]**
 6. **<Insert manufacturer's name>**

- C. General Requirements for Medical and Laboratory Gas-Service Connections:
1. All positive-pressure gas-service connections, for all gas types, are to be manufacturer cleaned, purged, and sealed as for oxygen service in accordance with CGA G-4.1.
 2. Suitable for specific gas pressure and suction service listed.
 3. Include roughing-in assemblies, finishing assemblies, and cover plates.
 4. Recessed-type units made for concealed piping unless otherwise indicated.
- D. Roughing-in Assembly:
1. Steel outlet box for recessed mounting and concealed piping.
 2. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
 3. Double seals that will prevent gas leakage.
 4. ASTM B819, **NPS 3/8 (DN 10)** copper outlet tube brazed to valve with service marking and tube-end dust cap.
- E. Finishing Assembly:
1. Brass housing with primary check valve.
 2. Double seals that will prevent gas leakage.
 3. Cover plate with gas-service label.
- F. Quick-Coupler Pressure Service Connections: Outlets for **[carbon dioxide][nitrous oxide][and][oxygen]<Insert type of gas>** with noninterchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.
- G. D.I.S.S. Pressure Service Connections: Outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
1. Medical Carbon Dioxide: D.I.S.S. No. 1080.
 2. Medical Helium: D.I.S.S. No. 1060.
 3. Medical Nitrogen: D.I.S.S. No. 1120.
 4. Medical Nitrous Oxide: D.I.S.S. No. 1040.
 5. Medical Oxygen: D.I.S.S. No. 1240.
 6. **<Insert medical gas>. <Insert D.I.S.S. No.>.**
- H. Cover Plates: One piece, **[aluminum][or][stainless steel]** and permanent, color-coded, identifying label matching corresponding service.

2.7 PATIENT-SERVICE CONSOLES

- A. Patient-Service Consoles :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Amico Corporation]**
 - b. **[BeaconMedaes]**
 - c. **[Tri-Tech Medical]**

- d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Amico Corporation]**
 - b. **[BeaconMedaes]**
 - c. **[Tri-Tech Medical]**
 - d. **<Insert manufacturer's name>**
3. Manufacturer cleaned, purged, and sealed, for all medical gas types, for oxygen service in accordance with CGA G-4.1.
4. Standard: UL 60601.
5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Mounting: **[Recessed][Semirecessed][Surface]**.
7. General Requirements for Patient-Service Consoles: Wall units with service connections. Include labels indicating services as well as the following:
 - a. Steel console box or mounting bracket.
 - b. Concealed supplies.
 - c. Cover: One piece, **[aluminum][plastic][or][stainless steel]** and permanent identifying label.
 - d. Medical gas-service connections, as specified in "Gas-Service Connections" Article.
 - 1) Medical Oxygen: **[One]<Insert number>[quick-coupler][D.I.S.S. No. 1240]** pressure outlet(s).
 - 2) Medical Air: **[One]<Insert number>[quick-coupler][D.I.S.S. No. 1160]** quick-coupler pressure outlet(s).
 - 3) Medical Vacuum: **[One]<Insert number>[quick-coupler][D.I.S.S. No. 1220]** suction inlet(s).
 - 4) Medical Vacuum Bottle Bracket(s): **[One]<Insert number>**.
- e. Electrical Service Connections:
 - 1) General Requirements for Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 - 2) Power Outlets: UL 498, Hospital Grade, 125 V ac, **[single][duplex]** receptacle(s); **in color selected by Architect**. Include the following configurations in accordance with NEMA WD 1:
 - a) **[One]<Insert number>** L5-20R, locking type, 20 A, single or duplex.
 - b) **[One]<Insert number>** L5-20R, isolated ground, locking type, 20 A, single or duplex.
 - c) **<Insert outlet type>**.
 - 3) Electrical Accessory Outlets: Provide the following configured receptacles in color selected by Architect:
 - a) Patient Equipment Ground Jack: **[One]<Insert number>**, single pole, 30 A.
 - b) Patient Monitoring: **[One]<Insert number>**, single, **[five][and][37]<Insert number>** pin.
 - c) **<Insert outlet type>**.

- 4) Outlet Cover Plates: One piece, **[aluminum][or][stainless steel]** and permanent identifying label.

2.8 NITROGEN PRESSURE-CONTROL PANELS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Allied Healthcare Products Inc.]**
 2. **[Amico Corporation]**
 3. **[BeaconMedaes]**
 4. **[Ohio Medical Corporation]**
 5. **[Tri-Tech Medical]**
 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Allied Healthcare Products Inc.]**
 2. **[Amico Corporation]**
 3. **[BeaconMedaes]**
 4. **[Ohio Medical Corporation]**
 5. **[Tri-Tech Medical]**
 6. **<Insert manufacturer's name>**
- C. Description: Steel box and support brackets for recessed roughing-in, with stainless steel or anodized-aluminum cover plate with printed operating instructions.
- D. Manifold: Assembly consisting of inlet supply valve, inlet supply pressure gauge, line-pressure control regulator, outlet supply pressure gauge, D.I.S.S. service connection, and piping outlet for remote service connection.
- E. Minimum Working Pressure: **[200 psig (1380 kPa)]<Insert value>**.
- F. Line-Pressure Control Regulator: Self-relieving diaphragm type with precision manual adjustment.
- G. Pressure Gauges: **0 to 300 psig (0 to 2070 kPa)**.
- H. Service Connection: CGA V-5, D.I.S.S. No. 1120, nitrogen outlet.
- I. Before final assembly, provide temporary dust shield and U-tube for testing.
- J. Label cover plate "Nitrogen Pressure Control."
- K. Manufacturer cleaned, purged, and sealed, for all gas types, for oxygen service in accordance with CGA G-4.1.

2.9 CEILING COLUMNS

- A. Ceiling Columns : **[Retractable][Stationary]**.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Amico Corporation]**
 - b. **[BeaconMedaes]**
 - c. **[Ohio Medical Corporation]**
 - d. **[Tri-Tech Medical]**
 - e. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Amico Corporation]**
 - b. **[BeaconMedaes]**
 - c. **[Ohio Medical Corporation]**
 - d. **[Tri-Tech Medical]**
 - e. **<Insert manufacturer's name>**

3. Description:
 - a. Manually adjustable, using release and lock handles capable of locking column in all positions from fully retracted to fully extended; **[15-inch- (380-mm-)]<Insert dimension>** long, rectangular, counterbalanced, telescoping section with **[two][four]<Insert number>** double intravenous medication hooks; and **[36-inch- (915-mm-)]<Insert dimension>** long fixed column section. Include **0.078-inch- (2.0-mm-)** thick, stainless steel bottom plate with medical gas and electrical service connections as required.
 - b. **[44-inch- (1120-mm-)]<Insert dimension>** long, rectangular stationary column section with **[two][four]<Insert number>** double intravenous medication hooks. Include **0.078-inch- (2.0-mm-)** thick, stainless steel bottom plate with medical gas and electrical service connections as required.
 - c. Medical Gas-Service Connections: As specified in "Gas-Service Connections" Article. Include labels indicating services.
 - 1) Medical Carbon Dioxide: **[One]<Insert number>[quick-coupler][D.I.S.S. No. 1080]** pressure outlet(s).
 - 2) Medical Helium: **[One]<Insert number>** D.I.S.S. No. 1060 pressure outlet(s).
 - 3) Medical Nitrogen: **[One]<Insert number>** D.I.S.S. No. 1120 pressure outlet(s).
 - 4) Medical Nitrous Oxide: **[One]<Insert number>[quick-coupler][D.I.S.S. No. 1040]** pressure outlet(s).
 - 5) Medical Oxygen: **[Two]<Insert number>[quick-coupler][D.I.S.S. No. 1240]** pressure outlets.
 - 6) Instrument Air: **[One]<Insert number>** D.I.S.S. No. 1160 pressure outlet(s).
 - 7) Medical Air: **[One]<Insert number>[quick-coupler][D.I.S.S. No. 1160]** pressure outlet(s).
 - 8) Medical Vacuum: **[Two]<Insert number>[quick-coupler][D.I.S.S. No. 1220]** suction inlets.
 - 9) Medical Vacuum Bottle Brackets: **[Two]<Insert number>**.
 - 10) WAGD: **[One]<Insert number>[quick-coupler][D.I.S.S. No. 2220]** suction inlet(s).
 - 11) **<Insert medical gas>: <Insert number and type>**.
 - d. Standard: UL 60601.
 - e. Manufacturer cleaned, purged, and sealed, for all medical gas type, for oxygen service in accordance with CGA G-4.1.

- f. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- g. Mounting: Ceiling-mounted units.
- h. Ceiling-Mounted Plate: Manufacturer's standard plate or roughing-in assembly.
- i. Exposed Surfaces: Minimum **0.0375-inch- (0.95-mm-)** thick stainless steel.
- j. Servicing: Include access panels or means of removing shroud.
- k. Blank cover plates for cutouts not having service connections.
- l. ASTM B819, **NPS 3/8 (DN 10)** copper-tube extensions for connection to medical gas systems.
- m. Service Connections: Type and number indicated.
- n. Dust Covers: For medical gas-service connections.
- o. Electrical Service Connections:
 - 1) Power Outlets: UL 498, Hospital Grade, 125 V ac, **[single][duplex]** receptacle(s); **in color selected by Architect**. Include the following configurations in accordance with NEMA WD 1:
 - a) **[One][Two]<Insert number>** L5-20R, locking type, 20 A, single or duplex.
 - b) **[One][Two]<Insert number>** L5-20R, isolated ground, locking type, 20 A, single or duplex.
 - c) **[One][Two]<Insert number>** explosion proof, 20 A, two pole, three wire, single; suitable for Class I, Group C hazardous location and interchangeable with receptacles used in nonhazardous areas; flush mounted.
 - d) **[One][Two]<Insert number>** 5-20R, straight blade, 20 A, duplex.
 - e) **[One][Two]<Insert number>** 5-20R, isolated ground, straight blade, 20 A, duplex.
 - f) **<Insert outlet type>**.
 - 2) Electrical Accessory Outlets: Provide the following configured receptacles **[in color selected by Architect]**:
 - a) Patient Equipment Ground Jack: **[One]<Insert number>**, single pole, 30 A.
 - b) Patient Monitoring: **[One]<Insert number>**, single, **[five][and][37]<Insert number>** pin.
 - c) **<Insert outlet type>**.
 - 3) Outlet Cover Plates: One piece, **[aluminum][or][stainless steel]** and permanent identifying label.

2.10 GAS MANIFOLDS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Acme Cryogenics]**
 - 2. **[Amico Corporation]**
 - 3. **[BeaconMedaes]**
 - 4. **[Ohio Medical Corporation]**
 - 5. **[Tri-Tech Medical]**
 - 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [Acme Cryogenics]
 2. [Amico Corporation]
 3. [BeaconMedaes]
 4. [Ohio Medical Corporation]
 5. [Tri-Tech Medical]
 6. <Insert manufacturer's name>
- C. Manufacturer cleaned, purged, and sealed, for all medical gas type, for oxygen service in accordance with CGA G-4.1.
- D. Comply with NFPA 99 for high-pressure medical gas cylinders.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. Central Control-Panel Unit:
1. Weatherproof cabinet.
 2. Supply and delivery pressure gauges.
 3. Electrical alarm-system connections and transformer.
 4. Indicator lights or devices.
 5. Manifold connection.
 6. Pressure changeover switch.
 7. Line-pressure regulator.
 8. Shutoff valves.
 9. Safety valve.
- G. Manifold and Headers:
1. Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks.
 2. Designed for [2000-psig (13.8-MPa)]<Insert value> minimum inlet pressure, except nitrous oxide manifolds may be designed for [800 psig (5520 kPa)]<Insert value>, and carbon dioxide manifolds may be designed for [1500 psig (10.35 MPa)]<Insert value>.
 3. Cylinder-bank headers with inlet (pigtail) connections complying with CGA V-1.
 4. Individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gauge.
- H. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder-bank header.
- I. Mounting: [Wall with mounting brackets for manifold control cabinet and headers][Floor with support legs for manifold control cabinet].
- J. Label manifold control unit with permanent label identifying medical gas type and system operating pressure.
- K. Laboratory and Medical Carbon Dioxide Manifolds: For [two][four]<Insert number> cylinders and [55-psig (380-kPa)]<Insert value> line pressure.
- L. Laboratory and Medical Helium Manifolds: For [two][four]<Insert number> cylinders and [55-psig (380-kPa)]<Insert value> line pressure.
- M. Laboratory and Medical Nitrogen Manifolds: For [eight][12]<Insert number> cylinders and [180-psig (1240-kPa)][higher than 200-psig (1380-kPa)]<Insert value> line pressure.
- N. Laboratory and Medical Nitrous Oxide Manifolds: For [eight][12]<Insert number> cylinders and [55-

psig (380-kPa)]<Insert value> line pressure, with electric heater or orifice design that will prevent freezing during high demand.

- O. Laboratory and Medical Oxygen Manifolds: For **[12][20]<Insert number>** cylinders and **[55-psig (380-kPa)]<Insert value>** line pressure.
- P. Laboratory and Medical Gas Cylinders: **[Furnished by Owner][Number and type of medical gas cylinders required for complete manifold systems]<Insert requirement>**.

2.11 SIMPLEX SPECIALTY GAS MANIFOLDS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Acme Cryogenics]**
2. **[Air Products and Chemicals, Inc.]**
3. **[Airgas; an Air Liquide company]**
4. **[BeaconMedaes]**
5. **[BOC Group, Inc.]**
6. **[CONCOA]**
7. **[GTS-Welco]**
8. **[Linde North America Inc]**
9. **[Matheson Tri-Gas, Inc.]**
10. **[Praxair Technology, Inc.]**
11. **[Spectra Gases, Inc.]**
12. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Acme Cryogenics]**
2. **[Air Products and Chemicals, Inc.]**
3. **[Airgas; an Air Liquide company]**
4. **[BeaconMedaes]**
5. **[BOC Group, Inc.]**
6. **[CONCOA]**
7. **[GTS-Welco]**
8. **[Linde North America Inc]**
9. **[Matheson Tri-Gas, Inc.]**
10. **[Praxair Technology, Inc.]**
11. **[Spectra Gases, Inc.]**
12. **<Insert manufacturer's name>**

- C. Manufacturer cleaned, purged, and sealed, for all medical gas type, for oxygen service in accordance with CGA G-4.1.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Control-Panel Unit: Weatherproof cabinet, supply and delivery pressure gauges, electrical alarm-system connections and transformer, indicator lights or devices, manifold connection, line-pressure regulator, shutoff valves, and safety valve.

- F. Manifold and Header: Nonferrous-metal header for number of cylinders indicated. Units include design for **[2000-psig (13.8-MPa)]<Insert value>** minimum inlet pressure, cylinder-bank header with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gauge.
- G. Mounting: **[Wall with mounting brackets for manifold control cabinet and header][Floor with support legs for manifold control cabinet]**.
- H. Label manifold control unit with permanent label identifying specialty gas type and system operating pressure.
- I. Manifold: For **<Insert specialty gas>**; one cylinder and **[55-psig (380-kPa)]<Insert value>** line pressure, with electric heater or orifice design that will prevent freezing during high demand.
- J. Specialty Gas Cylinders: **[Furnished by Owner][Number and type of specialty gas cylinders required for complete manifold systems]<Insert requirement>**.

2.12 DUPLEX SPECIALTY GAS MANIFOLDS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Acme Cryogenics]**
 - 2. **[Air Liquide America Specialty Gases LLC]**
 - 3. **[Air Products and Chemicals, Inc.]**
 - 4. **[Airgas; an Air Liquide company]**
 - 5. **[BeaconMedaes]**
 - 6. **[BOC Group, Inc.]**
 - 7. **[CONCOA]**
 - 8. **[GTS-Welco]**
 - 9. **[Linde North America Inc]**
 - 10. **[Matheson Tri-Gas, Inc.]**
 - 11. **[Praxair Technology, Inc.]**
 - 12. **[Spectra Gases, Inc.]**
 - 13. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Acme Cryogenics]**
 - 2. **[Air Liquide America Specialty Gases LLC]**
 - 3. **[Air Products and Chemicals, Inc.]**
 - 4. **[Airgas; an Air Liquide company]**
 - 5. **[BeaconMedaes]**
 - 6. **[BOC Group, Inc.]**
 - 7. **[CONCOA]**
 - 8. **[GTS-Welco]**
 - 9. **[Linde North America Inc]**
 - 10. **[Matheson Tri-Gas, Inc.]**
 - 11. **[Praxair Technology, Inc.]**
 - 12. **[Spectra Gases, Inc.]**
 - 13. **<Insert manufacturer's name>**
- C. Manufacturer cleaned, purged, and sealed, for all gas types, for oxygen service in accordance with CGA

G-4.1.

- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Central Control-Panel Unit: Weatherproof cabinet, supply and delivery pressure gauges, electrical alarm-system connections and transformer, indicator lights or devices, manifold connection, line-pressure regulator, shutoff valves, and safety valve.
- F. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for **[2000-psig (13.8-MPa)]<Insert value>** minimum inlet pressure, cylinder-bank headers with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gauge.
- G. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder-bank header.
- H. Mounting: **[Wall with mounting brackets for manifold control cabinet and headers][Floor with support legs for manifold control cabinet]**.
- I. Label manifold control unit with permanent label identifying specialty gas type and system operating pressure.
- J. Manifold: For **<Insert specialty gas>**; two cylinders and **[55-psig (380-kPa)]<Insert value>** line pressure, with electric heater or orifice design that will prevent freezing during high demand.
- K. Specialty Gas Cylinders: **[Furnished by Owner][Number and type of specialty gas cylinders required for complete manifold systems]<Insert requirement>**.

2.13 BULK MEDICAL GAS STORAGE TANKS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Acme Cryogenics]**
 - 2. **[Chart Industries]**
 - 3. **[Taylor-Wharton]**
 - 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Acme Cryogenics]**
 - 2. **[Chart Industries]**
 - 3. **[Taylor-Wharton]**
 - 4. **<Insert manufacturer's name>**
- C. General Requirements for Bulk Medical Gas Storage Tanks:
 - 1. Manufacturer cleaned, purged, and sealed, for all gas types, for oxygen service in accordance with CGA G-4.1.

2. Comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1; and NFPA 99.
 3. Include bulk storage tank with connections for alarm system, continuous supply, and reserve supply that will operate only during emergencies.
 4. Controls: Include actuating switch for alarm-system connection and means for automatic actuating of reserve supply.
 5. Bulk Gas Storage Tanks: Vertical mounted, double-wall construction with inner vessel fabricated in accordance with ASME Boiler and Pressure Vessel Code for unfired pressure vessels and suitable for gas service. Include insulation and vacuum seal between walls. Fabricate outer shell from carbon steel with factory-applied manufacturer's standard protective paint finish suitable for exterior installation. Include the following features, specialties, and components:
 - a. Safety Valves: ASME construction with pressure setting to correspond to tank working pressure and as required for component or system being protected.
 - b. Pressure Gauges: For tank pressure and facility service-line pressure.
 - c. Contents Gauge: High- and low-level indicator with electric signal circuit connection.
 - d. Drain Valves: For piping, inner vessel, and outer shell.
 - e. Fill Assembly: Fill connection, piping, valves, relief devices, and controls.
 - f. Facility Service Assembly: Piping, valves, relief devices, vaporizer, shutoff valve, pressure regulator, line shutoff valve or check valve, and reserve supply connection for connection to building service piping.
 - g. Permanent label showing medical gas type, storage-tank capacity, tank pressure rating, vaporizer capacity, and operating instructions.
- D. Liquid Oxygen Storage Tank:
1. Comply with NFPA 55 for bulk oxygen storage tanks.
 2. Construction: Nickel-steel or stainless steel inner vessel with **[250-psig (1725-kPa)]<Insert value>** minimum working pressure.
 3. Vaporizer Type: **[Electric][Steam][Ambient]**.
 4. Storage-Tank Capacity: **[As indicated]<Insert value>**.
 5. Vaporizer Capacity: **[As indicated]<Insert value>**.
- E. Oxygen Reserve Supply: Manifold header for high-pressure cylinders fabricated from copper-tube or brass pipe and fittings and suitable for pressures of up to **[4000 psig (27.6 MPa)]<Insert value>**. Include header inlet connections complying with CGA V-1, with individual inlet check valves, header shutoff valve, header pressure regulator, line shutoff valve or check valve, pressure gauge, and inlet connections for **<Insert number>** cylinders indicated.
- F. Liquid Nitrous Oxide Storage Tank:
1. Comply with CGA G-8.1 for bulk nitrous oxide storage tanks.
 2. Construction: Steel-alloy inner vessel with **[300-psig (2070-kPa)]<Insert value>** minimum working pressure.
 3. Vaporizer Type: **[Electric][Steam]**.
 4. Storage Tank Capacity: **[As indicated]<Insert value>**.
 5. Vaporizer Capacity: **[As indicated]<Insert value>**.
- G. Nitrous Oxide Reserve Supply: Manifold header for high-pressure cylinders fabricated from copper-tube or brass pipe and fittings and suitable for pressures of up to **[4000 psig (27.6 MPa)]<Insert value>**. Include header inlet connections complying with CGA V-1, with individual inlet check valves, header shutoff valve, header pressure regulator, line shutoff valve or check valve, pressure gauge, inlet connections for **<Insert number>** cylinders indicated, and electric heater.

2.14 GAS CYLINDER STORAGE RACKS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Airgas; an Air Liquide company]**
 2. **[RT Racking Systems]**
 3. **[USA Safety]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Airgas; an Air Liquide company]**
 2. **[RT Racking Systems]**
 3. **[USA Safety]**
 4. **<Insert manufacturer's name>**
- C. Wall Storage Racks: Fabricate racks with chain restraints for upright cylinders, as indicated, or provide equivalent manufactured wall racks.
- D. Freestanding Storage Racks: Fabricate racks as indicated, or provide equivalent manufactured storage racks.
- E. Anchor holes in base to permit securing to the floor with anchor bolts supplied by the manufacturer.
- F. Rack Support Tubing: Minimum **2-inch by 2-inch by 1/8-inch (50-mm by 50-mm by 3-mm)** tube steel finished with baked-on exterior grade polyurethane powder paint. All joints wrap-welded and polished.
- G. Tank Restraints: Dual minimum **5/16-inch (8-mm)** steel welded link chain, electrically zinc-plated rated for **1900 lb (860 kg)** with minimum **5/16-inch (8-mm)** zinc-plated carabineer hooks rated for minimum **520 lb (235 kg)**.
- H. Comply with NFPA 55.
- I. Comply with NFPA 99.
- J. Comply with OSHPD #OPA-2878-10.

PART 3 - EXECUTION**3.1 PREPARATION**

- A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
1. Clean medical gas tube and fittings, valves, gauges, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service in accordance with CGA G-4.1.
 2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of **1 lb (0.453 kg)** of chemical to **3 gal. (11.3 L)** of

water.

- a. Scrub to ensure complete cleaning.
- b. Rinse with clean, hot water to remove cleaning solution.

3.2 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling and for underground warning tapes.

3.3 INSTALLATION OF PIPING

- A. General Location and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of gas piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Comply with NFPA 99 for installation of medical gas piping.
- C. Comply with NFPA 55 for installation of laboratory gas piping.
- D. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- G. Install piping adjacent to equipment and specialties to allow service and maintenance.
- H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.
- I. Install piping to permit valve servicing.
- J. Install piping free of sags and bends.
- K. Install fittings for changes in direction and for branch connections.
- L. Install medical gas piping to medical gas-service connections specified in this Section, to medical gas-service connections in equipment specified in this Section, and to equipment specified in other Sections requiring medical gas service.
- M. Install exterior, buried medical gas piping in protective conduit fabricated with PVC pipe and fittings. Do not extend conduit through foundation wall.
- N. Piping Restraint Installation: Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- O. Install medical gas-service connections recessed in walls. Attach roughing-in assembly to substrate;

attach finishing assembly to roughing-in assembly.

- P. Connect gas piping to gas sources and to gas outlets and equipment requiring gas service.
- Q. Install unions in copper tubing adjacent to each valve and at final connection to each specialty and piece of equipment.
- R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220500 "Common Work Results for Plumbing."
- S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220500 "Common Work Results for Plumbing."
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220500 "Common Work Results for Plumbing."
- U. Prepare tubing and install fittings using tools by product manufacturer.

3.4 INSTALLATION OF VALVES

- A. Install shutoff valve at each connection to gas laboratory and healthcare equipment and specialties.
- B. Install check valves to maintain correct direction of gas flow from laboratory and healthcare gas supplies.
- C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.
- D. Install zone valves and gages in valve boxes. Arrange valves so largest valve is lowest. Rotate valves to angle that prevents closure of cover when valve is in closed position.
- E. Install pressure regulators on gas piping where reduced pressure is required.
- F. Install emergency oxygen connection with pressure-relief valve and full-size discharge piping to outside, with check valve downstream from pressure-relief valve, and with ball valve and check valve in supply main from bulk oxygen storage tank.

3.5 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.
- C. Threaded Joints: Apply appropriate tape to external pipe threads.
- D. Brazed Joints: Join copper tube and fittings in accordance with CDA's "Copper Tube Handbook," Ch. "Brazed Joints." Do not use flux. Continuously purge joint with oil-free, dry nitrogen during brazing.
- E. Shape-Memory-Metal Coupling Joints: Join new copper tube to existing tube in accordance with procedures developed by fitting manufacturer for installation of shape-memory-metal coupling joints.
- F. Soldered Joints: Apply ASTM B813, water-flushable flux to tube end. Join copper tube and fittings in

accordance with ASTM B828.

- G. Extruded-Tee Outlets: Form branches in copper tube in accordance with ASTM F2014, with tools recommended by tube manufacturer.
- H. Flanged Joints:
 - 1. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts in accordance with ASME B31.9 for bolting procedure.
 - 2. PVC Piping: Install PVC flange on PVC pipes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts in accordance with ASME B31.9 for bolting procedure.

3.6 INSTALLATION OF GAS-SERVICE COMPONENTS

- A. Assemble patient-service console with service connections. Install with supplies concealed in walls. Attach console box or mounting bracket to substrate.
- B. Install nitrogen pressure-control panels in walls. Attach to substrate.
- C. Assemble ceiling columns and install anchored to substrate. Provide structural steel, hanger rods, anchors, and fasteners in addition to components furnished with specialties necessary to fabricate supports.
- D. Assemble ceiling-hose assemblies and install anchored to substrate. Provide structural steel, hanger rods, anchors, and fasteners in addition to components furnished with specialties necessary to fabricate supports.
- E. Install gas manifolds[**on concrete base**] anchored to substrate.
- F. Install gas cylinders and connect to manifold piping.
- G. Install gas manifolds with seismic restraints.
- H. Install bulk gas storage tanks and reserve supply tanks level on concrete bases. Set tanks and connect gas piping to tanks[**in accordance with applicable requirements in NFPA 55 for bulk oxygen storage systems**]. Install tanks level and plumb, firmly anchored to concrete bases; maintain NFPA 55 and tank manufacturer's recommended clearances. Orient tanks, so controls and devices are accessible for servicing.
- I. Install bulk gas storage tanks and reserve supply tanks with seismic restraints.

3.7 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for hangers, supports, and anchor devices specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- C. Vertical Piping: MSS Type 8 or Type 42, clamps.
- D. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.

- E. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44 pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.
- F. Base of Vertical Piping: MSS Type 52 spring hangers.
- G. Install hangers for copper tubing with maximum horizontal spacing and minimum rod diameters to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- H. Support horizontal piping within **[12 inches (300 mm)]<Insert dimension>** of each fitting and coupling.
- I. Support vertical runs of copper tubing to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.8 IDENTIFICATION

- A. Install identifying labels and devices for specialty gas piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."
- B. Install identifying labels and devices for healthcare medical gas piping systems in accordance with NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
 1. Carbon Dioxide: Black or white letters on gray background.
 2. Helium: White letters on brown background.
 3. Nitrogen: White letters on black background.
 4. Nitrous Oxide: White letters on blue background.
 5. Oxygen: White letters on green background or green letters on white background.

3.9 FIELD QUALITY CONTROL FOR HEALTHCARE FACILITY MEDICAL GAS

- A. Testing Agency:
 1. Owner will engage a qualified testing agency to perform tests and inspections.
 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections **[with the assistance of a factory-authorized service representative]**.
- D. Tests and Inspections:
 1. Gas Piping Testing Coordination: Perform tests, inspections, verifications, and certification of medical gas piping systems concurrently with tests, inspections, and certification of **[medical compressed-air piping][and][medical vacuum piping]** systems.
 2. Preparation: Perform the following Installer tests in accordance with requirements in NFPA 99 and ASSE Standard #6010:

- a. Initial blowdown.
 - b. Initial pressure test.
 - c. Cross-connection test.
 - d. Piping purge test.
 - e. Standing pressure test for positive-pressure medical gas piping.
 - f. Standing pressure test for vacuum systems.
 - g. Repair leaks and retest until no leaks exist.
3. System Verification: Perform the following tests and inspections in accordance with NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:
 - a. Standing pressure test.
 - b. **[Individual-pressurization][or][pressure-differential]** cross-connection test.
 - c. Valve test.
 - d. Master and area alarm tests.
 - e. Piping purge test.
 - f. Piping particulate test.
 - g. Piping purity test.
 - h. Final tie-in test.
 - i. Operational pressure test.
 - j. Gas concentration test.
 - k. Air-purity test.
 - l. Verify correct labeling of equipment and components.
 - m. Verify medical gas supply sources.
4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed, and certify report results. Include the following:
 - a. Inspections performed.
 - b. Procedures, materials, and gases used.
 - c. Test methods used.
 - d. Results of tests.

E. Piping will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.10 FIELD QUALITY CONTROL FOR LABORATORY FACILITY SPECIALTY GAS

- A. Testing Agency:
 1. Owner will engage a qualified testing agency to perform tests and inspections.
 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 1. Piping Leak Tests for Specialty Gas Piping: Test new and modified parts of existing piping. Cap and fill specialty gas piping with oil-free, dry nitrogen to pressure of **50 psig (345 kPa)** above system operating pressure, but not less than **[150 psig (1035 kPa)]<Insert value>**. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test

- pressure; hold for two hours with no drop in pressure.
- 2. Repair leaks and retest until no leaks exist.
- 3. Inspect specialty gas regulators for proper operation.

- E. Piping will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.11 PROTECTION

- A. Protect tubing from damage.
- B. Retain sealing plugs in tubing, fittings, and specialties until installation.
- C. Clean tubing not properly sealed, and where sealing is damaged, in accordance with "Preparation" Article.

3.12 DEMONSTRATION

- A. **[Engage factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain bulk gas storage tanks.

3.13 PIPING SCHEDULE

- A. Connect new tubing to existing tubing with memory-metal couplings.
- B. Medical Gas Piping except Medical Nitrogen Piping Larger Than NPS 3 (DN 80) and Operating at More Than 185 psig (1275 kPa): Type L, copper tube; wrought-copper fittings; and brazed joints.
- C. Medical Nitrogen Piping Larger Than NPS 3 (DN 80) and Operating at More Than 185 psig (1275 kPa): Type K, copper tube; wrought-copper fittings; and brazed joints.
- D. Specialty Gas Piping except Specialty Gas Larger Than NPS 3 (DN 80) and Operating at More Than 185 psig (1275 kPa): Type L, copper tube; wrought-copper fittings; and brazed joints.
- E. Specialty Gas Piping Larger Than NPS 3 (DN 80) and Operating at More Than 185 psig (1275 kPa): Type K, copper tube; wrought-copper fittings; and brazed joints.
- F. Laboratory Gas Piping except Laboratory Nitrogen Piping NPS 3 (DN 80) and Smaller Operating at More Than 185 psig (1275 kPa): Type L, copper tube; wrought-copper fittings; and brazed joints.
- G. Laboratory Nitrogen Piping NPS 3 (DN 80) and Smaller to Operate at More Than 185 psig (1275 kPa): Type K, copper tube; wrought-copper fittings; and brazed joints.
- H. **<Insert specialty gas>**. Piping except Specialty Gas NPS 3 (DN 80) and Smaller to Operate at More Than 185 psig (1275 kPa): Type L, copper tube; wrought-copper fittings; and brazed joints.
- I. **<Insert specialty gas>**. Piping NPS 3 (DN 80) and Smaller to Operate at More Than 185 psig (1275 kPa): Type K, copper tube; wrought-copper fittings; and brazed joints.



3.14 VALVE SCHEDULE

- A. Shutoff Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions.
- B. Zone Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions with pressure gauge on one copper-tube extension.

END OF SECTION 22 63 13 00



THIS PAGE INTENTIONALLY LEFT BLANK



Task	Specification	Specification Description
22 63 13 53	22 63 13 00	Gas Piping For Laboratory And Healthcare Facilities
22 63 13 70	22 63 13 00	Gas Piping For Laboratory And Healthcare Facilities



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 66 00 00 - CHEMICAL-WASTE SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall pipe and fittings.
2. Double-wall containment pipe and fittings.
3. Field-fabrication containment piping.
4. Joining materials.
5. Piping specialties.
6. Neutralization tanks.
7. Neutralization systems.
8. Manholes - holding tanks.
9. Leak-detection systems.
10. pH monitoring systems.
11. High-level alarm stations.
12. Combination high-level and leak-detection alarm stations.

1.2 DEFINITIONS

- A. FPM: Vinylidene fluoride (hexafluoropropylene copolymer rubber).

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- B. Shop Drawings: For neutralization system, leak-detection systems, and pH monitoring systems and level alarms.

1. Include plans, elevations, sections, and attachment details.
2. Include details of neutralization-system assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details of leak-detection-system assemblies. Indicate required clearances, method of field assembly, components, and location and size of each field connection.
4. Include diagrams for power, signal, and control wiring.

- C. Delegated Design Submittals: For seismic restraints of aboveground piping.

1. Include design calculations for selecting seismic restraints. See Section 018123 "Facility Seismic and Wind Criteria" for building seismic and wind criteria.

- D. Sustainable Design Submittals:

1. Product Data: For solvents and adhesives, indicating VOC content.
2. Laboratory Test Reports: For solvents and adhesives, indicating compliance with requirements

for low-emitting materials.

1.4 INFORMATIONAL SUBMITTALS

- A. Profile Drawings for Outdoor Underground Piping: Show system piping in elevation. Draw profiles at horizontal scale of not less than **1 inch equals 50 feet (1:500)** and vertical scale of not less than **1 inch equals 5 feet (1:50)**. Indicate underground structures and pipes. Show types, sizes, materials, and elevations of other utilities crossing system piping.
- B. Coordination Drawings: Plans and other details, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.
- C. Seismic Qualification Certificates: For tanks and tank systems, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Field quality control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For chemical-waste specialties and **[neutralization tanks][neutralization systems][and][leak-detection systems]** to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Neutralization-Tank Limestone: Equal to **[200]<Insert number>** percent of amount required for each tank sump initial charge. Furnish limestone in **50 lb (22.7 kg)** bags.
 - 2. Neutralization-System Limestone and Chemicals: For each neutralization system.
 - a. Limestone: Equal to **[500]<Insert number>** percent of amount required for tank sump initial charge. Furnish limestone in **50 lb (22.7 kg)** bags.
 - b. Chemicals: Equal to **[500][1000]<Insert number>** percent of neutralizing chemicals required for filling tanks.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store piping and specialties with sealing plugs in ends or with end protection.
- B. Do not store plastic pipe or fittings in direct sunlight.

- C. Protect pipe, fittings, and seals from dirt and damage.

1.8 FIELD CONDITIONS

- A. Interruption of Existing Chemical-Waste Service: Do not interrupt chemical-waste service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary chemical-waste service in accordance with requirements indicated:
 - 1. Notify **[Architect][Construction Manager][Owner]** no fewer than **[two]<Insert number>** days in advance of proposed interruption of chemical-waste service.
 - 2. Do not proceed with interruption of chemical-waste service without **[Architect's][Construction Manager's][Owner's]** written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Single-Wall Piping Pressure Rating: **[5 psig (34.5 kPa)]<Insert value>[air test pressure][10 feet head (3.05 m)]of water for 30 minutes<Insert value and time>**.
- B. Double-Containment Piping Pressure Rating:
 - 1. Carrier Piping: **[5 psig (34.5 kPa)]<Insert value>[air test pressure][10 feet head (3.05 m) of water for 30 minutes]<Insert value and time>**.
 - 2. Containment Piping: **[5 psig (34.5 kPa)]<Insert value>[air test pressure]<Insert test method>**.
- C. Field-Fabrication Containment-Piping Pressure Rating: **[5 psig (34.5 kPa)]<Insert value>[air test pressure]<Insert test method>**.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- E. NFPA Compliance: Comply with NFPA 70.
- F. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic restraints for aboveground piping. See Section 018123 "Facility Seismic and Wind Criteria," which specifies basis-of-design seismic and wind criteria for non-structural components.
- G. Seismic Performance: Piping, piping specialties, tanks, and tank systems are to withstand the effects of earthquake motions. See Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]**."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 SINGLE-WALL PIPE AND FITTINGS

- A. PP Drainage Pipe and Fittings: ASTM F1412, extruded pipe and drainage-pattern fittings molded, with Schedule 40 dimensions and with fire-retardant additive complying with ASTM D4101; with **[fusion-][and][mechanical-]joint ends**.
1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.
 2. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[GF Piping Systems: Georg Fischer LLC]**
 - b. **[IPEX USA LLC]**
 - c. **[Orion Fittings; A Watts Water Technologies Company]**
 - d. **[Town & Country Plastics, Inc]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
 3. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[GF Piping Systems: Georg Fischer LLC]**
 - b. **[IPEX USA LLC]**
 - c. **[Orion Fittings; A Watts Water Technologies Company]**
 - d. **[Town & Country Plastics, Inc]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
 4. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.
- B. CPVC Drainage Pipe and Fittings: ASTM F2618, pipe and drainage-pattern fittings.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Charlotte Pipe and Foundry Company]**
 - b. **[Spears Manufacturing Company]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Charlotte Pipe and Foundry Company]**
 - b. **[Spears Manufacturing Company]**
 - c. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.

- C. PVDF Drainage Pipe and Fittings: ASTM F1673, Schedule 40, pipe and drainage-pattern fittings. Include fittings with **[fusion-][and][mechanical-]**joint ends.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[GF Piping Systems: Georg Fischer LLC]**
 - b. **[IPEX USA LLC]**
 - c. **[Orion Fittings; A Watts Water Technologies Company]**
 - d. **[Zurn Industries, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[GF Piping Systems: Georg Fischer LLC]**
 - b. **[IPEX USA LLC]**
 - c. **[Orion Fittings; A Watts Water Technologies Company]**
 - d. **[Zurn Industries, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.
- D. Fiberglass Pipe and Fittings, Centrifugally Cast: ASTM D2997, Type II, **[Grade 1][Grade 2]<Insert grade>**, **[Class A][Class B][Class C]**, RTRP pipe; with ASTM D5685, Type 4, fiberglass thermosetting resin fittings matching pipe; and **[adhesive-bonding][and][butt-and-wrap-joint]** materials. Include wall thickness that will provide **[160 psig (1105 kPa)]<Insert value>** minimum, sustained water test pressure rating.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Smith Fiberglass; a National Oilwell Varco brand]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Smith Fiberglass; a National Oilwell Varco brand]**
 - b. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.
- E. Fiberglass Pipe and Fittings, Filament Wound: ASTM D2996, Type I, **[Grade 1][Grade 2]<Insert grade>**, **[Class A][Class B][Class C][Class E][Class F]<Insert class>**, RTRP pipe; ASTM D5685, Type 1, reinforced thermosetting resin fittings matching pipe; and **[adhesive-bonding][and][butt-and-wrap-joint]** materials. Include wall thickness that will provide **[160 psig (1105 kPa)]<Insert value>** minimum, sustained water test pressure rating.



1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ameron International]**
 - b. **[Fibrex]**
 - c. **[Smith Fiberglass; a National Oilwell Varco brand]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ameron International]**
 - b. **[Fibrex]**
 - c. **[Smith Fiberglass; a National Oilwell Varco brand]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.
- F. Stainless Steel Drainage Pipe and Fittings: ASME A112.3.1, ASTM A666, Type 316L, stainless steel pipe and drainage-pattern fittings; with socket-and-spigot ends for gasket joints; and having piping manufacturer's FPM lip-seal rubber gaskets shaped to fit socket groove, with plastic backup ring.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Josam Company]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Josam Company]**
 - b. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.
- G. Borosilicate Glass Pipe and Fittings: ASTM C1053, pipe and drainage-pattern fittings; with manufacturer's standard couplings.
1. Covering: Factory-applied polystyrene for pipe installed underground.
 2. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Schott North America, Inc.]**
 - b. **<Insert manufacturer's name>**

3. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Schott North America, Inc.]**
 - b. **<Insert manufacturer's name>**
4. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.
- H. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, and gaskets; compatible with piping and system liquid; made for joining different piping materials.

2.3 DOUBLE-WALL CONTAINMENT PIPE AND FITTINGS

A. Double-Wall Containment Pipe and Fittings - Factory Fabricated:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Asahi/America]**
 - b. **[Flo Safe, Inc]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[Insul-Tek Piping Systems, Inc]**
 - e. **[IPEX USA LLC]**
 - f. **[Orion Fittings; A Watts Water Technologies Company]**
 - g. **[Performance Pipe]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Asahi/America]**
 - b. **[Flo Safe, Inc]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[Insul-Tek Piping Systems, Inc]**
 - e. **[IPEX USA LLC]**
 - f. **[Orion Fittings; A Watts Water Technologies Company]**
 - g. **[Performance Pipe]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.
4. Sizes indicate carrier-pipe size; with carrier (inner) pipe and fittings; annular-space, carrier-pipe supports; containment (outer) pipe and fittings; and joining materials and fasteners.
5. Piping Materials:
 - a. PP Double-Containment Drainage Pipe and Fittings: Made of ASTM D4101 PP resin.
 - 1) Carrier and Containment Pipes: ASTM F1412, Schedule 40.
 - 2) Fittings: ASTM F1412, Schedule 40 drainage pattern complying with ASTM D3311.

- b. PVDF Double-Containment Drainage Pipe and Fittings: Made of ASTM D3222 PVDF resin.
 - 1) Carrier and Containment Pipes: ASTM F1673, Schedule 40.
 - 2) Fittings: ASTM F1673, Schedule 40 drainage pattern complying with ASTM D3311.
- 6. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.

2.4 FIELD-FABRICATION CONTAINMENT PIPING

- A. Containment Piping - Field Fabricated: Containment split pipe and split fittings with carrier-pipe centralizers. Include manufacturer's fastening devices and materials.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Flo Safe, Inc]**
 - b. **[GF Piping Systems: Georg Fischer LLC]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Flo Safe, Inc]**
 - b. **[GF Piping Systems: Georg Fischer LLC]**
 - c. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain containment piping from single source from single manufacturer.
 - 4. Material: **[HDPE][PP]** pipe and fittings.
 - 5. Fastening System: FPM gaskets, clamps, and pins.

2.5 JOINING MATERIALS

- A. Couplings: Assemblies with combinations of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.
- B. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.
- C. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.
- D. Solvent Cement for Joining CPVC Piping: ASTM F493. Include primer in accordance with ASTM F656.
 - 1. Product Data: Verify PVC welding solvent cement has a VOC content of 510 g/L or less.
 - 2. Verify solvent cement complies with testing and product requirements of the California

3. Verify solvent cement complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 4. Verify solvent cement complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.
- E. Fiberglass-Pipe Adhesive: As furnished or recommended by pipe manufacturer.
1. Verify fiberglass adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).
 2. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 3. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 4. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.

2.6 PIPING SPECIALTIES

- A. Plastic Dilution Traps:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[GF Piping Systems: Georg Fischer LLC]**
 - b. **[IPEX USA LLC]**
 - c. **[Orion Fittings; A Watts Water Technologies Company]**
 - d. **[Town & Country Plastics, Inc]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[GF Piping Systems: Georg Fischer LLC]**
 - b. **[IPEX USA LLC]**
 - c. **[Orion Fittings; A Watts Water Technologies Company]**
 - d. **[Town & Country Plastics, Inc]**
 - e. **[Zurn Industries, LLC]**



f. <Insert manufacturer's name>

3. Source Limitations: Obtain traps from single source from single manufacturer.
4. Material: Corrosion-resistant PP, with removable base.
5. End Connections: Mechanical joint.
6. Dilution Tanks: **1 gal. (3.8 L)** capacity, with clear base unless colored base is indicated; with two **NPS 1-1/2 (DN 40)** top inlets and one **NPS 1-1/2 (DN 40)** side outlet.
7. Small Dilution Jars: **1-pint (0.5-L)** capacity, with clear base unless colored base is indicated; with **NPS 1-1/2 (DN 40)** top inlet and **NPS 1-1/2 (DN 40)** side outlet.
8. Large Dilution Jars: **1-quart (1-L)** capacity; with **NPS 1-1/2 (DN 40)** top inlet and **NPS 1-1/2 (DN 40)** side outlet.

B. Glass, Drain-Line, Interceptor Traps:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Schott North America, Inc.]**
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert **manufacturer's name; product name or designation**> or comparable product by one of the following:
 - a. **[Schott North America, Inc.]**
 - b. <Insert manufacturer's name>
3. Source Limitations: Obtain traps from single source from single manufacturer.
4. Standard: ASTM C1053.
5. Type: Drum trap.
6. Size: **NPS 1-1/2 (DN 40), NPS 2 by NPS 1-1/2 (DN 50 by DN 40), or NPS 2 (DN 50)**, as required to match connecting piping.

C. Corrosion-Resistant Traps:

1. Type: P-trap or drum trap.
2. Size: **NPS 1-1/2 or NPS 2 (DN 40 or DN 50)**, as required to match connected piping.
3. High-Silicon Iron: ASTM A861, with horizontal outlet and hub-and-plain or plain ends to match connecting piping.
4. PP: ASTM D4101, with mechanical-joint pipe connections.
5. PVDF: ASTM D3222, with mechanical-joint pipe connections.
6. Glass: ASTM C1053, with coupling pipe connections.

D. Stainless Steel Floor Drains :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Josam Company]**
 - b. **[Sioux Chief Manufacturing Company, Inc.]**

- c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Josam Company]**
 - b. **[Sioux Chief Manufacturing Company, Inc.]**
 - c. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain floor drains from single source from single manufacturer.
 4. Standard: ASME A112.3.1; ASTM A666, Type 316L.
 5. Body: With **[8.5-by-8.5-inch (215-by-215-mm)][12.4-by-12.4-inch (315-by-315-mm)]** top with grate.
 6. Outlet: Bottom, of size indicated.
- E. PP Floor Drains :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[GF Piping Systems: Georg Fischer LLC]**
 - b. **[IPEX USA LLC]**
 - c. **[Orion Fittings; A Watts Water Technologies Company]**
 - d. **[Schier Products Company]**
 - e. **[Town & Country Plastics, Inc]**
 - f. **[WATTS; A Watts Water Technologies Company]**
 - g. **[Zurn Industries, LLC]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[GF Piping Systems: Georg Fischer LLC]**
 - b. **[IPEX USA LLC]**
 - c. **[Orion Fittings; A Watts Water Technologies Company]**
 - d. **[Schier Products Company]**
 - e. **[Town & Country Plastics, Inc]**
 - f. **[WATTS; A Watts Water Technologies Company]**
 - g. **[Zurn Industries, LLC]**
 - h. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain floor drains from single source from single manufacturer.
 4. Body: With **7- to 9-inch (178- to 230-mm)** top diameter, with flashing flange and weep holes; and with **[flashing clamp][basket strainer][funnel attachment][and][trap-primer connection]**.
 5. Outlet: Bottom, to match connecting pipe, with **NPS 2, NPS 3, NPS 4, or NPS 6 (DN 50, DN 80, DN 100, or DN 150)** outlet as indicated.
- F. Stainless Steel Cleanouts:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Josam Company]
- b. [Sioux Chief Manufacturing Company, Inc.]
- c. <Insert manufacturer's name>

- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Josam Company]
- b. [Sioux Chief Manufacturing Company, Inc.]
- c. <Insert manufacturer's name>

- 3. Source Limitations: Obtain cleanouts from single source from single manufacturer.
- 4. Standard: ASME A112.3.1; ASTM A666, Type 316L.
- 5. Aboveground Piping: Cleanout tee of size matching piping.
- 6. Underground and Underslab Piping: Floor access cleanout of size matching piping.

G. Plastic Backwater Valves:

- 1. Description: Full-port **NPS 3 (DN 80)** check valve, PP or PVDF, matching or compatible with system piping and compatible with system liquid, with EPDM seals and flanged ends.
 - a. Exception: PVC material for use with PVC piping systems.

H. PP Sink Outlets:

- 1. Description: **NPS 1-1/2 (DN 40)**, with clamping device, stopper, and **7-inch- (178-mm-)** high overflow fitting.

I. Glass Sink Outlets:

- 1. **NPS 1-1/2 (DN 40)**; with sink assembly of outlet, strainer, gasket, and locknut; overflow fitting of length indicated; and tailpiece assembly of borosilicate glass and locknut.
- 2. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Schott North America, Inc.]
- b. <Insert manufacturer's name>

- 3. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Schott North America, Inc.]
- b. <Insert manufacturer's name>

- 4. Source Limitations: Obtain sink outlets from single source from single manufacturer.
- 5. Standard: ASTM C1053 components for field assembly.

2.7 NEUTRALIZATION TANKS

A. Plastic Neutralization Tanks :

1. Corrosion-resistant plastic materials; with removable, gastight cover; interior, sidewall, dip-tube inlet; outlet; vent; and threaded or flanged, sidewall pipe connections.
2. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Chem-Tainer Industries]**
 - b. **[GF Piping Systems: Georg Fischer LLC]**
 - c. **[IPEX USA LLC]**
 - d. **[Orion Fittings; A Watts Water Technologies Company]**
 - e. **[Schier Products Company]**
 - f. **[Town & Country Plastics, Inc]**
 - g. **[WATTS; A Watts Water Technologies Company]**
 - h. **[Zurn Industries, LLC]**
 - i. **<Insert manufacturer's name>**
3. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Chem-Tainer Industries]**
 - b. **[GF Piping Systems: Georg Fischer LLC]**
 - c. **[IPEX USA LLC]**
 - d. **[Orion Fittings; A Watts Water Technologies Company]**
 - e. **[Schier Products Company]**
 - f. **[Town & Country Plastics, Inc]**
 - g. **[WATTS; A Watts Water Technologies Company]**
 - h. **[Zurn Industries, LLC]**
 - i. **<Insert manufacturer's name>**
4. Source Limitations: Obtain tanks from single source from single manufacturer.
5. Material: **[HDPE][HDPE or ASTM D4101 PP][ASTM D4101 PP]**.
6. Tank Capacity: **<Insert capacity>**.
7. Dip Tube: On outlet pipe instead of inlet pipe.
8. Extension: HDPE, PE, or PP.
9. Traffic Cover: **[Light-duty][Heavy-duty pedestrian or light-duty vehicular, steel plate over] plastic, bolted.**
10. Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
11. Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.

B. Ceramic Neutralization Tanks :

1. Corrosion-resistant, cast-ceramic shell; with removable, reinforced-plastic, gastight cover; inlet; interior, sidewall, dip-tube outlet; vent; and bell, sidewall pipe connections.
2. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**



- a. **[Koch Knight LLC]**
- b. **<Insert manufacturer's name>**

- 3. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Koch Knight LLC]**
- b. **<Insert manufacturer's name>**

- 4. Source Limitations: Obtain tanks from single source from single manufacturer.
- 5. Tank Capacity: **<Insert capacity>**.
- 6. Extension, Ceramic: Of size and length indicated, and with cast-iron manhole frame and cover.
- 7. Extension, Steel: With protective coating, **28-inch (710-mm)** diameter, and cast-iron manhole frame and cover.
- 8. Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and **1- to 3-inch (25- to 75-mm)** diameter.
- 9. Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and **1- to 3-inch (25- to 75-mm)** diameter.

- C. Collection Tanks: Corrosion-resistant, cast-ceramic shell. Include removable, reinforced-plastic, gastight cover; inlet; vent; and bell, sidewall pipe connections.

- 1. Extension: **[Ceramic][Steel with protective coating]**, **28-inch (710-mm)** minimum diameter, and cast-iron manhole frame and cover.

2.8 NEUTRALIZATION SYSTEMS

A. Plastic-Tank Neutralization Systems :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Orion Fittings; A Watts Water Technologies Company]**
- b. **[Town & Country Plastics, Inc]**
- c. **[Zurn Industries, LLC]**
- d. **<Insert manufacturer's name>**

- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Orion Fittings; A Watts Water Technologies Company]**
- b. **[Town & Country Plastics, Inc]**
- c. **[Zurn Industries, LLC]**
- d. **<Insert manufacturer's name>**

- 3. Source Limitations: Obtain neutralization systems from single source from single manufacturer.
- 4. Description: Automatic system for neutralizing chemical waste.
- 5. Controls: Factory wired and tested, 120 V ac, to operate probes, control valves, and metering

6. pumps and to monitor pH of effluent; with wiring and electrical-power terminals.
Panel: NEMA 250, Type 4X enclosure unless otherwise indicated; with manufacturer's standard features, control devices, and indicators, but not less than the following:
 - a. Power light and on/off switch.
 - b. pH analyzer with meter and high- and low-pH indicators.
 - c. Low caustic- and acid-solution level indicators.
 - d. Alarm horn with silencer and reset switch.
 - e. Agitator running light with on/off switch.
 - f. Running lights with on/off switches for caustic- and acid-solution pumps.
 7. Strip chart recorder with capacity for 30-day record.
 8. Piping between Tanks: Same material as chemical-waste piping system unless otherwise indicated.
 9. Interceptor Tank: Same material as mixing tank; with removable, gastight cover and sidewall inlet and outlet piping connections.
 10. Neutralization Tank: Same material as mixing tank; with removable, gastight cover, sidewall inlet and outlet piping connections, and vent connection in sidewall or top.
 - a. Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and **1- to 3-inch (25- to 75-mm)** diameter.
 - b. Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and **1- to 3-inch (25- to 75-mm)** diameter.
 11. Mixing Tank: With removable, gastight cover, sidewall inlet and outlet piping connections, vent connection in sidewall or top, neutralizing-solution piping connections, and openings in top for probe and agitator.
 - a. Material: **[HDPE][HDPE or ASTM D4101 PP][ASTM D4101 PP]**.
 - b. pH Probe: Type and length suitable for mixing-tank size.
 - c. Agitator: Electric, with stainless steel shaft and propeller.
 12. Caustic-Solution Storage Tank: PP.
 - a. Caustic Chemical: Sodium hydroxide solution.
 13. Acid Storage Tank: PP.
 - a. Acid Chemical: Sulfuric acid solution.
 14. Metering Pumps: Types suitable for neutralizing solutions.
 15. Sampling Tank: Same material as mixing tank; with removable, gastight cover, sidewall inlet and outlet piping connections, and opening in top for probe.
 - a. pH probe: Type and length suitable for sampling-tank size.
- B. Ceramic-Tank Neutralization Systems :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Koch Knight LLC]**

- b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Koch Knight LLC]
 - b. <Insert manufacturer's name>
3. Source Limitations: Obtain neutralization systems from single source from single manufacturer.
4. Description: Automatic system for neutralizing chemical waste.
5. Controls: Factory wired and tested, 120 V ac, to operate probes, control valves, and metering pumps and to monitor pH of effluent; with wiring and electrical-power terminals.
6. Panel: NEMA 250, Type 4X enclosure unless otherwise indicated; with manufacturer's standard features, control devices, and indicators, but not less than the following:
 - a. Power light and on/off switch.
 - b. pH analyzer with meter and high- and low-pH indicators.
 - c. Low caustic- and acid-solution level indicators.
 - d. Alarm horn with silencer and reset switch.
 - e. Agitator running light with on/off switch.
 - f. Running lights with on/off switches for caustic- and acid-solution pumps.
7. Strip chart recorder with capacity for 30-day record.
8. Piping between Tanks: Same material as chemical-waste piping system unless otherwise indicated.
9. Interceptor Tank: Same material as mixing tank; with removable, gastight cover and sidewall inlet and outlet piping connections.
10. Neutralization Tank: Same material as mixing tank; with removable, gastight cover, sidewall inlet and outlet piping connections, and vent connection in sidewall or top.
 - a. Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
 - b. Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
11. Mixing Tank: With removable, gastight cover, sidewall inlet and outlet piping connections, vent connection in sidewall or top, neutralizing-solution piping connections. and openings in top for probe and agitator.
 - a. Material: Clay, vitrified into ceramic unit.
 - b. pH Probe: Type and length suitable for mixing tank size.
 - c. Agitator: Electric, with stainless steel shaft and propeller.
12. Caustic-Solution Storage Tank: PP.
 - a. Caustic Chemical: Sodium hydroxide solution.
13. Acid Storage Tank: PP.
 - a. Acid Chemical: Sulfuric acid solution.
14. Metering Pumps: Types suitable for neutralizing solutions.

15. Sampling Tank: Same material as mixing tank; with removable, gastight cover, sidewall inlet and outlet piping connections, and opening in top for probe.

a. pH Probe: Type and length suitable for sampling-tank size.

2.9 MANHOLES - HOLDING TANKS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Ayer Sales, Inc.]**
2. **[ISCO Industries, LLC]**
3. **[Performance Pipe]**
4. **[Plastic Fusion Fabricators, Inc]**
5. **[PolyPipe Brand; Dura-Line]**
6. **[Zurn Industries, LLC]**
7. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Ayer Sales, Inc.]**
2. **[ISCO Industries, LLC]**
3. **[Performance Pipe]**
4. **[Plastic Fusion Fabricators, Inc]**
5. **[PolyPipe Brand; Dura-Line]**
6. **[Zurn Industries, LLC]**
7. **<Insert manufacturer's name>**

C. Source Limitations: Obtain holding tanks from single source from single manufacturer.

D. Description: ASTM F1759, fabricated from PE components. Include bottom, sidewalls, and top sections; corrosion-resistant, tanks frame and cover; fusion or other watertight joints; and design to prohibit flotation.

E. Construction: **[Single wall][Double wall with interstitial space]**.

F. Bottom: Channeled.

G. Connections: Inlets and outlet matching or suitable for piping.

H. Steps: Manufacturer's standard, fusion welded to sidewall. Omit steps for manholes less than **[60 inches (1500 mm)]<Insert dimension>** deep.

I. Top: Include **24-inch (610-mm)** nominal-diameter frame and cover.

2.10 LEAK-DETECTION SYSTEMS

A. Leak-Detection Systems :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Asahi/America]
 - b. [Flo Safe, Inc]
 - c. [IPEX USA LLC]
 - d. [Pentair Thermal Management]
 - e. [PermAlert]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Asahi/America]
 - b. [Flo Safe, Inc]
 - c. [IPEX USA LLC]
 - d. [Pentair Thermal Management]
 - e. [PermAlert]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain leak-detection systems from single source from single manufacturer.
4. Description: Cable leak-detection system capable of detecting and annunciating fluid leaks; with controls, panel, wiring, cable sensors, probes if required, and piping.
5. Annunciator Panel: Enclosure with visual and audible alarms and leak-location indicator.
6. Sensors: Electric cable, suitable for insertion in double-containment piping annular space, with capability of detecting fluid leaks and signaling locations of leaks.

2.11 pH MONITORING SYSTEMS

A. pH Monitoring System:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [IPEX USA LLC]
 - b. [Orion Fittings; A Watts Water Technologies Company]
 - c. [Process and Water]
 - d. [Sensorex USA]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [IPEX USA LLC]
 - b. [Orion Fittings; A Watts Water Technologies Company]
 - c. [Process and Water]
 - d. [Sensorex USA]
 - e. <Insert manufacturer's name>

3. Description: pH monitoring system, including monitoring panel, pH probe, and interconnecting cable.
4. Monitoring Panel:
 - a. Enclosure: UL 508 listed and labeled, <Insert enclosure type>.
 - b. pH analyzer.
 - c. Power-on LED.
 - d. Alarms:
 - 1) User-selectable high and low pH setpoints.
 - 2) Analyzer/sensor fault alarm.
 - 3) Red visible alarm indicator lights.
 - 4) Audible alarm horn.
 - 5) Audible alarm silence button.
 - e. Digital pH Chart Recorder Module:
 - 1) Fully connected and installed in monitoring panel.
 - 2) Paperless chart recorder.
 - 3) 30-day record.
 - 4) User-selectable high and low alarm set points.
 - 5) Enclosure: <Insert enclosure type>.
5. pH Probe and Cable:
 - a. Industrial-quality pH probe.
 - b. Airtight insertion fixture.
 - c. Factory-calibrated.

2.12 HIGH-LEVEL ALARM STATIONS

A. High-Level Alarm Station:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Icon Process Controls]
 - b. [MIFAB, Inc]
 - c. [Orion Fittings; A Watts Water Technologies Company]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Icon Process Controls]
 - b. [MIFAB, Inc]
 - c. [Orion Fittings; A Watts Water Technologies Company]
 - d. <Insert manufacturer's name>
3. Description: High-level alarm stations for tanks.

4. Alarm Panel:
 - a. Enclosure: UL-listed, **<Insert enclosure type>**.
 - b. 120 V ac, 60 Hz.
 - c. Integral Alarm Horn: **<Insert decibels at distance>**.
 - d. Integral red-light beacon that remains active until alarm state is resolved.
 - e. Horn silence switch.
 - f. Alarm test switch.
5. High-Level Alarm Sensor:
 - a. Polypropylene NO float sensor with solid polypropylene exposed float.
 - b. Maximum Operating Temperature: **[194 deg F (90 deg C)]<Insert maximum operating temperature>**.

B. Combination High-Level and Leak-Detection Alarm Stations:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Icon Process Controls]**
 - b. **[Orion Fittings; A Watts Water Technologies Company]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Icon Process Controls]**
 - b. **[Orion Fittings; A Watts Water Technologies Company]**
 - c. **<Insert manufacturer's name>**
3. Description: Combination high level alarm and leak detection station for tanks.
4. Alarm Panel:
 - a. Enclosure: UL-listed, **<Insert enclosure type>**.
 - b. 120 V ac, 60 Hz.
 - c. Green, power-on LED.
 - d. Two red, alarm LEDs that remain active until alarm state is resolved.
 - e. Integral alarm horn, **<Insert decibels at distance>**
 - f. Horn silence switch.
 - g. Alarm test switch.
 - h. System Operating Temperature Range: **[Minus 22 deg F to plus 150 deg F (Minus 30 deg C to plus 65 deg C)]<Insert range>**.
5. High-Level Alarm Sensor:
 - a. Polypropylene normally open float sensor with solid polypropylene exposed float.
6. Leak-Detection Sensor:

- a. For sensing leaks on floor around outside perimeter of tank.
- b. 12 V dc flat leak detection sensor.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 CONCRETE BASES

- A. Equipment Mounting:

- 1. Install **[neutralization tanks][and][neutralization system tanks]** on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- 3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

- B. Anchor **[neutralization tanks][and][neutralization system tanks]** to concrete bases.

- 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **19-inch (480-mm)** centers around full perimeter of base.
- 2. For installed equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
- 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be imbedded.
- 4. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.3 INSTALLATION OF PIPING

- A. Chemical-Waste Sewerage Outside the Building:

- 1. Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground chemical-waste sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- 2. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's written instructions for using lubricants, cements, and other installation requirements.
- 3. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- 4. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- 5. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or combination of both.

6. Install drainage piping pitched down in direction of flow, at minimum slope of [1][2]<Insert number> percent unless otherwise indicated.
7. Install drainage piping with [36-inch (900-mm)][48-inch (1200-mm)][60-inch (1500-mm)][72-inch (1800-mm)]<Insert dimension> minimum cover.
8. Install CPVC drainage piping in accordance with ASTM D2321 and ASTM F1668.
9. Install PVDF drainage piping in accordance with ASTM D2321 and ASTM F1668.
10. Install field-fabrication containment piping over[new and] existing carrier piping. Use containment piping manufacturer's fastening system.
11. Clear interior of piping and structures of dirt and superfluous material as work progresses. Maintain a swab or drag inside piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

B. Chemical-Waste Piping Inside the Building:

1. Install piping adjacent to equipment, accessories, and specialties, to allow space for service and maintenance.
2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
3. Flanges may be used on aboveground piping unless otherwise indicated.
4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.
10. Verify final equipment locations for roughing-in.
11. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220500 "Common Work Results for Plumbing."
12. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220500 "Common Work Results for Plumbing."
13. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220500 "Common Work Results for Plumbing."

3.4 INSTALLATION OF PIPING SPECIALTY

- A. Embed floor drains in **4-inch- (100-mm-)** minimum depth of concrete around bottom and sides. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for concrete.
- B. Fasten grates to drains if indicated.
- C. Set floor drains with tops flush with pavement surface.
- D. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.
 1. Set cleanout bodies in earth in cast-in-place concrete block, **18 by 18 by 12 inches (450 by 450 by 300 mm)** deep. Set with tops **1 inch (25 mm)** above surrounding grade. Set cleanout plugs in concrete pavement, with tops flush with pavement surface. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for formwork, reinforcement, and

concrete requirements.

- E. Install backwater valves in horizontal position. Include riser to cleanout at grade.

3.5 JOINT CONSTRUCTION

- A. Chemical-Waste Sewerage Outside the Building:

- 1. Plastic-Piping Fusion Joints: Make PP drainage-piping joints in accordance with ASTM F1290.
 - 2. Join dissimilar pipe materials with adapters compatible with pipe materials being joined.

- B. Chemical-Waste Piping Inside the Building:

- 1. Plastic-Piping Fusion Joints: Make PP drainage-piping joints in accordance with ASTM F1290.
 - 2. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.

3.6 INSTALLATION OF HANGER AND SUPPORT

- A. Pipe sizes in this article refer to aboveground single-wall piping[**and carrier piping of containment piping**].
- B. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
- C. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. Install the following:
 - 1. Vertical Piping: MSS Type 8 or MSS Type 42 riser clamps.
 - 2. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52 spring hangers.
- D. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for installation of supports.
- E. Support horizontal piping and tubing within **12 inches (300 mm)** of each fitting and coupling.
- F. Support vertical piping and tubing at base and at each floor.
- G. Rod diameter may be reduced one size for double-rod hangers, to minimum of **3/8 inch (10 mm)**.
- H. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 2 (DN 50): **33 inches (840 mm)** with **3/8-inch (10-mm)** rod.

2. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): **42 inches (1067 mm)** with **1/2-inch (13-mm)** rod.
 3. NPS 4 and NPS 5 (DN 100 and DN 125): **48 inches (1220 mm)** with **5/8-inch (16-mm)** rod.
 4. NPS 6 (DN 150): **48 inches (1220 mm)** with **3/4-inch (19-mm)** rod.
 5. NPS 8 (DN 200): **48 inches (1220 mm)** with **7/8-inch (22-mm)** rod.
- I. Install supports for vertical PP piping every **72 inches (1830 mm)**.
- J. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): **36 inches (910 mm)** with **3/8-inch (10-mm)** rod.
 2. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): **42 inches (1070 mm)** with **1/2-inch (13-mm)** rod.
 3. NPS 4 and NPS 5 (DN 100 and DN 125): **48 inches (1220 mm)** with **5/8-inch (16-mm)** rod.
 4. NPS 6 (DN 150): **48 inches (1220 mm)** with **3/4-inch (19-mm)** rod.
 5. NPS 8 to NPS 12 (DN 200 to DN 300): **48 inches (1220 mm)** with **7/8-inch (22-mm)** rod.
- K. Install supports for vertical CPVC piping every **48 inches (1220 mm)**.
- L. Install vinyl-coated hangers for PVDF piping with the following maximum horizontal spacing and minimum rod diameters:
1. All Sizes: Install continuous support for piping with liquid waste at temperatures above **140 deg F (60 deg C)**.
 2. NPS 1/2 (DN 15) and Smaller: **30 inches (760 mm)** with **3/8-inch (10-mm)** rod.
 3. NPS 3/4 to NPS 1-1/2 (DN 20 to DN 40): **36 inches (910 mm)** with **3/8-inch (10-mm)** rod.
 4. NPS 2 (DN 50): **36 inches (910 mm)** with **3/8-inch (10-mm)** rod.
 5. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): **42 inches (1070 mm)** with **1/2-inch (13-mm)** rod.
 6. NPS 4 and NPS 5 (DN 100 and DN 125): **48 inches (1220 mm)** with **5/8-inch (16-mm)** rod.
 7. NPS 6 (DN 150): **48 inches (1220 mm)** with **3/4-inch (19-mm)** rod.
- M. Install supports for vertical PVDF piping **NPS 1-1/2 (DN 40)** every **48 inches (1220 mm)** and **NPS 2 (DN 50)** and larger every **72 inches (1830 mm)**.
- N. Install hangers for stainless steel drainage piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 2 (DN 50): **10 feet (3 m)** with **3/8-inch (10-mm)** rod.
 2. NPS 2-1/2 (DN 65): **11 feet (3.4 m)** with **1/2-inch (13-mm)** rod.
 3. NPS 3 (DN 80): **12 feet (3.6 m)** with **1/2-inch (13-mm)** rod.
 4. NPS 4 and NPS 5 (DN 100 and DN 125): **12 feet (3.6 m)** with **5/8-inch (16-mm)** rod.
 5. NPS 6 (DN 150): **12 feet (3.6 m)** with **3/4-inch (19-mm)** rod.
- O. Install supports for vertical, stainless steel drainage piping every **15 feet (4.5 m)**.
- P. Install vinyl-coated hangers for glass piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): **72 inches (1830 mm)** with **3/8-inch (10-mm)** rod.
 2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): **96 inches (2440 mm)** with **3/8-inch (10-mm)** rod.
 3. NPS 3 (DN 80): **96 inches (2440 mm)** with **1/2-inch (13-mm)** rod.
 4. NPS 4 and NPS 6 (DN 100 and DN 150): **96 inches (2440 mm)** with **5/8-inch (16-mm)** rod.
- Q. Install supports for vertical glass piping every **96 inches (2440 mm)**.

- R. Support piping and tubing not listed above in accordance with MSS SP-58.

3.7 INSTALLATION OF NEUTRALIZATION TANK

- A. Install exterior **[collection][and][neutralization]** tanks, complete with appurtenances indicated.
1. Set tops of tank covers flush with finished surface where covers occur in pavements. Set covers **3 inches (75 mm)** above finished surface elsewhere unless otherwise indicated.
 2. Include initial fill of limestone for neutralization tanks.
- B. Install interior neutralization tanks on smooth and level **[concrete base][floor surface]**. Include full initial charge of limestone.

3.8 INSTALLATION OF NEUTRALIZATION SYSTEM

- A. Install neutralization systems on smooth and level **[concrete base][floor surface]**. Include neutralizing solutions and full initial charge of limestone.

3.9 INSTALLATION OF MANHOLE - HOLDING TANK

- A. General: Install tanks, complete with appurtenances and accessories indicated. Comply with requirements in Section 333115 "Site Sanitary Sewerage Piping."
- B. Set tops of tank frames and covers flush with finished surface where tanks occur in pavements. Set tops **3 inches (76 mm)** above finished surface elsewhere unless otherwise indicated.

3.10 INSTALLATION OF LEAK-DETECTION SYSTEM

- A. Single-Pipe, Chemical-Waste Sewerage Piping: Install leak-detection system below piping.
- B. Double-Containment Piping: Install leak-detection system in piping annular space.
- C. Tanks: Install leak-detection system around bottom of exterior.
- D. Install panel in location indicated.

3.11 CONCRETE PLACEMENT

- A. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for concrete supports.
- B. Place cast-in-place concrete in accordance with ACI 318/318R.

3.12 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Make connections to existing piping, so finished Work complies as nearly as practical with requirements specified for new Work.

- C. Use commercially manufactured wye fittings for sewerage piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting plus **6-inch (150-mm)** overlap, with not less than **6 inches (150 mm)** of concrete with 28-day compressive strength of **[3000 psi (20.7 MPa)]<Insert value>**.
- D. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.
- E. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.13 LABELING AND IDENTIFICATION

- A. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.
 - 1. Use[**warning tape or**] detectable warning tape over ferrous piping.
 - 2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.14 ADJUSTING

- A. Adjust neutralization-system set points.
- B. Adjust leak-detection-system control and device settings.

3.15 CLEANING

- A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:
 - 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - 2. Clean piping by flushing with potable water.

3.16 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service for **[neutralization systems][and][leak-detection systems]**.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Neutralization Systems:
 - a. Verify that neutralization system is installed and connected according to the Contract Documents.
 - b. Verify that electrical wiring installation complies with manufacturer's submittal.
 - c. Install neutralizing solutions and limestone.
 - d. Energize circuits.
 - e. Start and run systems through complete sequence of operations.
 - f. Adjust operating controls.
 - g. **<Insert startup steps if any>**.

3. Leak-Detection Systems:

- a. Verify that electrical wiring installation complies with manufacturer's submittal.
- b. Energize circuits.
- c. Adjust operating controls.
- d. **<Insert startup steps if any>.**

3.17 FIELD QUALITY CONTROL

- A. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately **24 inches (610 mm)** of backfill is in place and again at completion of Project.

1. Defects requiring correction include the following:

- a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.
- b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
- c. Crushed, broken, cracked, or otherwise damaged piping.
- d. Hydrostatic Tests for Drainage Piping:
 - 1) Allowable leakage is a maximum of **[50 gal./inch of nominal pipe size per mile (4.6 L/mm of nominal pipe size per kilometer)]<Insert value>** of pipe during 24-hour period.
 - 2) Close openings in system and fill with water.
 - 3) Purge air and refill with water.
 - 4) Disconnect water supply.
 - 5) Test and inspect joints for leaks.

- e. Air Tests for Drainage Piping: Comply with UNI-B-6.

2. Leaks and loss in test pressure constitute defects that must be repaired.
3. Submit separate reports for each test.

- B. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.

- C. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.

- D. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

- E. Perform tests and inspections with the assistance of a factory-authorized service representative.

F. Tests and Inspections:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect assembled **[neutralization systems][and][leak-detection systems]** and their installation, including piping and electrical connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and

equipment.

- G. Chemical-waste piping will be considered defective if it does not pass tests and inspections.
- H. Prepare test and inspection reports.

3.18 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain **[neutralization systems][and][leak-detection systems]**.

3.19 PIPING SCHEDULE

- A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.
- B. Single-Wall, Chemical-Waste Sewerage Piping: Use **[any of]** the following piping materials for each size range:
 - 1. NPS 2 to NPS 4 (DN 50 to DN 100) Stainless Steel: Drainage pipe and fittings and gasketed joints.
 - 2. NPS 1-1/2 to NPS 4 (DN 40 to DN 100) PP: Drainage pipe and fittings and fusion joints.
 - 3. NPS 1-1/2 to NPS 4 (DN 40 to DN 100) CPVC: Drainage pipe and fittings and solvent-cemented joints.
 - 4. NPS 1-1/2 to NPS 4 (DN 40 to DN 100) PVDF: Drainage pipe and fittings and fusion joints.
 - 5. NPS 2 to NPS 4 (DN 50 to DN 100) Fiberglass: **[Centrifugally cast][Filament-wound]** fiberglass pipe and fittings and **[butt-and-wrap][bonded]** joints.
 - 6. NPS 1-1/2 to NPS 4 (DN 40 to DN 100) Glass: Glass pipe and fittings and coupled joints.
 - 7. NPS 6 (DN 150) Stainless Steel: Drainage pipe and fittings and gasketed joints.
 - 8. NPS 6 (DN 150) PP: Drainage pipe and fittings and fusion joints.
 - 9. NPS 6 (DN 150) PVDF: Drainage pipe and fittings and fusion joints.
 - 10. NPS 6 (DN 150) Fiberglass: **[Centrifugally cast][Filament-wound]** fiberglass pipe and fittings and **[butt-and-wrap][bonded]** joints.
 - 11. NPS 6 (DN 150) Glass: Pipe and fittings and coupled joints.
 - 12. NPS 8 to NPS 12 (DN 200 to DN 300) PP: Drainage pipe and fittings and fusion joints.
 - 13. NPS 8 to NPS 12 (DN 200 to DN 300) PVDF: Drainage pipe and fittings and fusion joints.
 - 14. NPS 8 to NPS 12 (DN 200 to DN 300) Fiberglass: **[Centrifugally cast][Filament-wound]** fiberglass pipe and fittings and **[butt-and-wrap][bonded]** joints.
- C. Underground, Double-Containment, Chemical-Waste Sewerage Piping: Use **[any of]** the following piping materials for each size range:
 - 1. NPS 2 to NPS 12 (DN 50 to DN 300) PP: Double-containment drainage pipe and fittings.
 - 2. NPS 2 to NPS 12 (DN 50 to DN 300) CPVC: Double-containment drainage pipe and fittings.
 - 3. NPS 2 to NPS 12 (DN 50 to DN 300) PVDF: Double-containment drainage pipe and fittings.
 - 4. NPS 2 to NPS 12 (DN 50 to DN 300) PVDF/CPVC: Double-containment drainage pipe and fittings.
- D. Aboveground Chemical-Waste Piping: Use **[any of]** the following piping materials for each size range:
 - 1. NPS 1-1/2 to NPS 6 (DN 40 to DN 150) PP: Drainage piping and **[fusion][mechanical]** joints.

2. NPS 1-1/2 to NPS 6 (DN 40 to DN 150) CPVC: Drainage piping and solvent-cemented joints.
 3. NPS 1-1/2 to NPS 6 (DN 40 to DN 150) PVDF: Drainage piping and [fusion][mechanical] joints.
 4. NPS 1-1/2 to NPS 6 (DN 40 to DN 150) Stainless Steel: Use **NPS 2 to NPS 4 (DN 50 to DN 100)** stainless steel drainage piping with socket-and-spigot ends and gasketed joints.
 5. NPS 1-1/2 to NPS 6 (DN 40 to DN 150) Borosilicate Glass: Pipe and fittings, couplings, and coupled joints.
- E. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use[**any of**] the following piping materials for each size range:
1. NPS 1-1/2 to NPS 6 (DN 40 to DN 150) PP: Drainage piping and fusion joints.
 2. NPS 1-1/2 to NPS 6 (DN 40 to DN 150) PVDF: Drainage piping and fusion joints.
 3. NPS 1-1/2 to NPS 6 (DN 40 to DN 150) Stainless Steel: Drainage piping with socket-and-spigot ends and gasketed joints.
 4. NPS 1-1/2 to NPS 6 (DN 40 to DN 150) Borosilicate Glass: Piping with covering, couplings, and coupled joints.
 5. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): [PP][PVDF] double-containment drainage piping and manufacturer's standard joints.
 6. NPS 8 (DN 200): [PP][PVDF] double-containment drainage piping and manufacturer's standard joints.

END OF SECTION 22 66 00 00



THIS PAGE INTENTIONALLY LEFT BLANK



Task	Specification	Specification Description
22 66 53 00	21 05 00 00	Common Work Results for Fire Suppression
22 66 53 00	22 05 00 00	Common Work Results for Plumbing
22 66 53 00	22 13 16 00	Sanitary Waste And Vent Piping
22 66 53 00	22 15 13 00	General-Service Compressed-Air Piping
22 66 53 00	22 66 00 00	Chemical-Waste Systems for Laboratory and Healthcare Facilities
22 66 53 00	23 05 00 00	Common Work Results for HVAC
22 66 83 00	22 66 00 00	Chemical-Waste Systems for Laboratory and Healthcare Facilities
22 66 83 16	22 66 00 00	Chemical-Waste Systems for Laboratory and Healthcare Facilities



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 67 00 00 - PROCESSED WATER EQUIPMENT FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes **[reagent-water][deionized-water][distilled-water][and][reverse-osmosis-water]** equipment and processed water faucets. Equipment and associated control and accessories shall be capable of producing **[Type 1][Type 2][Type 3]** reagent grade water.
 - 1. Multimedia filter.
 - 2. Carbon filter.
 - 3. Water softeners.
 - 4. Dechlorination filter.
 - 5. Deionized (DI) mixed beds.
 - 6. RO systems.
 - 7. Recirculating pump.
 - 8. Purified-water storage tank
 - 9. Point-of-use portable polishers.
 - 10. Ultra-violet sterilization unit.
 - 11. Recirculating pure-water faucet.
- B. Related Requirements:
 - 1. Section 226713 "Processed Water Piping for Laboratory and Healthcare Facilities" for piping, fittings and valves.

1.2 DEFINITIONS

- A. RO: Reverse osmosis.

1.3 ACTION SUBMITTALS

- A. Product Data for each type of product, including the following.
 - 1. Pump curves.
 - 2. Equipment dimensions and weight data.
 - 3. Electrical wiring data.
 - 4. Control panel layout.
 - 5. Vibration data.
- B. Sustainable Design Submittals:
 - 1. Product Data: For solvents and adhesives, indicating VOC content.
 - 2. Laboratory Test Reports: For solvents and adhesives, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings:

1. Provide a flow schematic of the proposed system, showing:
 - a. Equipment and accessories.
 - b. Piping and directional flows and sizes.
 - c. Flow rates.
 - d. Connection to domestic water.
 - e. Components.
 - f. Interconnection piping.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: For equipment, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Field quality-control reports.
- C. Operation and Maintenance Data: For all equipment in this section.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer shall have the qualifications for supplying and servicing process water equipment, including engineering services.
- B. The process water quality shall be in accordance with ASTM D1193.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain processed water equipment from single source.

2.2 PERFORMANCE REQUIREMENTS

- A. Design equipment based on the city of **<Insert city>** make-up water conditions obtained from the city water supply quality report.
 1. Reagent-Water Piping: **[20 psig (138 kPa)][40 psig (276 kPa)][50 psig (345 kPa)][100 psig (690 kPa)]<Insert pressure>** unless otherwise indicated.
 2. Deionized-Water Piping: **[50 psig (345 kPa)][100 psig (690 kPa)][150 psig (1035 kPa)]<Insert pressure>** unless otherwise indicated.
 3. Distilled-Water Piping: **[50 psig (345 kPa)][100 psig (690 kPa)][150 psig (1035 kPa)]<Insert pressure>** unless otherwise indicated.
 4. RO Water Piping: **[50 psig (345 kPa)][100 psig (690 kPa)][150 psig (1035 kPa)]<Insert pressure>** unless otherwise indicated.

- B. Seismic Performance: Water piping shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
1. The term "withstand" means "the equipment will remain in place without separation of any parts when subjected to the seismic forces specified[**and the equipment will be fully operational after the seismic event**]."
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.3 MULTIMEDIA FILTRATION

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Aqua Pure Water Conditioning]**
2. **[Diamond Water Conditioning; a Griesbach company]**
3. **[Everfilt]**
4. **[LAKOS Filtration Solutions]**
5. **[Miami Filter, Inc.]**
6. **[MWF Metro Water Filter]**
7. **[PEP Filters, Inc.]**
8. **[Puroflux Corporation]**
9. **[Sonitec-Vortisand Inc.]**
10. **[United Industries, Inc; Tower-flo Water Systems]**
11. **[Water Professionals]**
12. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Aqua Pure Water Conditioning]**
2. **[Diamond Water Conditioning; a Griesbach company]**
3. **[Everfilt]**
4. **[LAKOS Filtration Solutions]**
5. **[Miami Filter, Inc.]**
6. **[MWF Metro Water Filter]**
7. **[PEP Filters, Inc.]**
8. **[Puroflux Corporation]**
9. **[Sonitec-Vortisand Inc.]**
10. **[United Industries, Inc; Tower-flo Water Systems]**
11. **[Water Professionals]**
12. **<Insert manufacturer's name>**

- C. Filter Tank:

1. Material: Fiberglass with a polyethylene liner and inner shell constructed of HDPE.
2. Rated Working Pressure: **[125 psig (860 kPa)][150 psig (1034 kPa)]** psig at 120 deg F (49 deg C) temperature.

- D. Distributor Assembly:

1. Hub and Lateral Distribution System:

- a. For tanks **21 inches (5333 mm)** in diameter and larger.
- b. Material: ABS or PVC.

2. Single Nonclogging Segmented Distributor:

- a. For tanks **18 inches (457 mm)** in diameter and smaller.
- b. Material: ABS.

E. Operating Valves:

1. Fully Automatic Multiport Control Valve:

- a. Motor-driven single-piston valve with a piston timer to control regeneration program.
- b. Fully adjustable.

2. Diaphragm Valves: Permit separate water source for backwashing.

F. Regeneration Initiation Control:

1. Provide a seven-day time clock to allow the system to regenerate at any time of the day or night and on any day of the week.
2. Provide a differential pressure switch to initiate backwash based on measurement of increased pressure loss across the system.

G. Filter Media:

1. Top Layer: 1.0- to 1.2-mm anthracite.
2. Second Layer: 0.4- to 0.5-mm flint sand.
3. Third Layer: 0.35- to 0.45-mm garnet.
4. All Layers: Resting on coarse gravel underbedding.

2.4 CARBON FILTER

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[ADCOA]**
2. **[EVOQUA Water Technologies]**
3. **[Gremarco Industries, Inc.]**
4. **[Omnipure Filter Company]**
5. **[United Filters International]**
6. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[ADCOA]**
2. **[EVOQUA Water Technologies]**
3. **[Gremarco Industries, Inc.]**
4. **[Omnipure Filter Company]**
5. **[United Filters International]**

6. <Insert manufacturer's name>

C. Filter Tank:

1. Welded, industrial-grade, cold-rolled carbon steel with dished heads constructed and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Rules for Construction of Pressure Vessels. Tank shall have the maximum working pressure of not less the [125 psig (862 kPa)][150 psig (1034 kPa)].
2. Filter Media:
 - a. Two layers of graduated supporting gravel.
 - b. One layer of [2 cu. ft. (56 L)]<Insert number> of activated carbon.
 - c. Bottom layer of coarse gravel underbedding.
3. The tank shall be provided with O-Ring seals at the openings, inlets, and outlets.
4. Tank shall have an epoxy enamel finish.
5. Provide seven-day time clock to allow the system to regenerate at any time of the day or night and on any day of the week.

2.5 WATER SOFTENERS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [3M]
2. [CSI Water Treatment Systems]
3. [Culligan International Company]
4. [Diamond Water Conditioning; a Griesbach company]
5. [Ecodyne Limited]
6. [EVOQUA Water Technologies]
7. [Hungerford & Terry, Inc]
8. [Hydro Service and Supplies]
9. [Kinetico Incorporated]
10. [Marlo Incorporated]
11. [Parker Boiler]
12. [Pentair, Inc.]
13. [RainSoft]
14. [Water King]
15. [WATTS; A Watts Water Technologies Company]
16. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [3M]
2. [CSI Water Treatment Systems]
3. [Culligan International Company]
4. [Diamond Water Conditioning; a Griesbach company]
5. [Ecodyne Limited]
6. [EVOQUA Water Technologies]
7. [Hungerford & Terry, Inc]
8. [Hydro Service and Supplies]
9. [Kinetico Incorporated]

10. [Marlo Incorporated]
11. [Parker Boiler]
12. [Pentair, Inc.]
13. [RainSoft]
14. [Water King]
15. [WATTS; A Watts Water Technologies Company]
16. <Insert manufacturer's name>

C. Standards: Comply with NSF 44.

D. Softener Tank: [Welded, industrial-grade, cold-rolled carbon steel][Fiberglass-reinforced polyester (FRP)].

1. [120-psig (827-kPa)][150-psig (1034-kPa)] operating pressure and ASME stamped.
2. Design at a temperature of 120 deg°F.
3. Tank to be lined with 20-mil-thick vinyl bag.
4. Mineral Bed: Non-phenolic polystyrene resin with a minimum exchange capacity of [30,000]<Insert number> grains per cubic foot when regenerated with [7 lbs (3.2 kg)][15 lbs (6.8 kg)] of salt per cubic foot (m[3]). Mineral shall be solid and particle the proper size, not more than 4 percent through a No. 40 mesh wet screening, and shall not contain any foreign shapes that will interfere with the normal operation of the softener.

E. Brine Tank: Shall be molded rigid polyethylene with cover, sized to hold <Insert lb (kg)> of salt per cubic foot. Tanks shall be furnished with a metering system, valves, and controls.

2.6 DECHLORINATION FILTER

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Culligan International Company]
2. [EVOQUA Water Technologies]
3. [Hydro Service and Supplies]
4. [Marlo Incorporated]
5. [WATTS; A Watts Water Technologies Company]
6. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Culligan International Company]
2. [EVOQUA Water Technologies]
3. [Hydro Service and Supplies]
4. [Marlo Incorporated]
5. [WATTS; A Watts Water Technologies Company]
6. <Insert manufacturer's name>

C. Filter: Two independent, activated carbon filters in parallel. Resultant residual chlorine concentration shall be less than 0.1 ppm.

D. Filter Vessel: Fiberglass-reinforced molded-thermoplastic inner shell with dished heads, equipped with reinforced openings for piping connections.

1. Hand hole at the top and bottom.
 2. Vessel to be rated at **150-psig (1034-kPa)** working pressure in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Rules for Construction of Pressure Vessels.
- E. Provide controls compatible with the facility control system. Provide connection for trouble alarm.
- F. Provide pressure gauges with simple cocks on inlet and outlet of each tank.

2.7 DEIONIZED (DI) MIXED BEDS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Culligan International Company]**
 2. **[EVOQUA Water Technologies]**
 3. **[Hydro Service and Supplies]**
 4. **[Marlo Incorporated]**
 5. **[WATTS; A Watts Water Technologies Company]**
 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Culligan International Company]**
 2. **[EVOQUA Water Technologies]**
 3. **[Hydro Service and Supplies]**
 4. **[Marlo Incorporated]**
 5. **[WATTS; A Watts Water Technologies Company]**
 6. **<Insert manufacturer's name>**
- C. Tank:
1. Material: Reinforced fiberglass with vinyl ester lining for removing dissolved ionized solids.
 2. Minimum Water Resistivity: 10 megohm - cm at 25 deg C.
 3. Pressure Ratings: Operating pressure of not less than **[125 psig (861 kPa)][150 psig (1034 kPa)]** and test pressure not less than **185 psig (1275 kPa)**.
- D. Resin: Suitable for using in mixed-bed deionizer application and for intended application.

2.8 REVERSE OSMOSIS (RO) SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[3M]**
 2. **[CSI Water Treatment Systems]**
 3. **[Culligan International Company]**
 4. **[Diamond Water Conditioning; a Griesbach company]**
 5. **[Ecodyne Limited]**
 6. **[EVOQUA Water Technologies]**



7. [Hydro Service and Supplies]
8. [Marlo Incorporated]
9. [Pentair, Inc.]
10. [Water & Power Technologies Incorporated]
11. [Water King]
12. [WATTS; A Watts Water Technologies Company]
13. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [3M]
2. [CSI Water Treatment Systems]
3. [Culligan International Company]
4. [Diamond Water Conditioning; a Griesbach company]
5. [Ecodyne Limited]
6. [EVOQUA Water Technologies]
7. [Hydro Service and Supplies]
8. [Marlo Incorporated]
9. [Pentair, Inc.]
10. [Water & Power Technologies Incorporated]
11. [Water King]
12. [WATTS; A Watts Water Technologies Company]
13. <Insert manufacturer's name>

C. Pressurized Membrane System: High-pressure pump forces water through the membrane(s) to remove 99 percent of organic solids, bacteria, contaminants, and particles and 97 percent of dissolved solids.

D. Pre-filtration: Polypropylene depth filters, capable of removing 90 percent of particles greater than 5 micron.

1. Housing:
 - a. [Type 304][Type 316] stainless steel.
 - b. Include vent and drain plugs with EPDM o-rings.
 - c. Include [Type 304][Type 316] pressure gauge at the inlet and outlet.

E. Membrane modules with thin-film composite type membranes and membrane vessels to allow a maximum flux for the following:

1. First State: [18 gallons per square foot per day (733 liters per square meter per day)]<Insert capacity> of membrane surface area at [17]<Insert number> percent recovery.
2. Second Stage: [30 gallons per square foot (114 liters per square meter per day)]<Insert number> per day of membrane surface area at [35]<Insert number> percent recovery.

F. Panel-Mounted Controls and Instrumentation on a Common Frame:

1. Material: [Stainless steel][Epoxy-coated aluminum].
2. Features:
 - a. Flow meters
 - b. [Type 304][Type 316] stainless steel pressure gauges for pump discharge and regulated pump pressure.
 - c. Control valves.

- d. Pump starter with indicated light.
- e. Feedwater pressure switch with time delay for low-pressure shutdown.
- f. Time controller for automatic fast flush.
- g. Monitor/controller with selector switch for feed to monitor conductivity.
- h. Trouble alarm with ability to connect to the building management system.

2.9 PURIFIED-WATER STORAGE TANK

- A. Material: Fabricated of molded polyethylene with a cone bottom and extra heavy wall construction. Provide with **[two][four]** lifting lugs of **[Type 304][Type 316]** stainless steel.
- B. Mounting: Steel stand assembly with hold-down lugs of **[Type 304][Type 316]** stainless steel.

2.10 RECIRCULATING PUMP

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Goulds Water Technology; a Xylem brand]**
 - 2. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Goulds Water Technology; a Xylem brand]**
 - 2. **<Insert manufacturer's name>**
- C. Type: **[Vertical][Horizontal]**.
- D. Pump Material: **[Type 304][Type 316]** stainless steel.
- E. Impeller Material: Stainless steel.
- F. Seals: Mechanical.
- G. Gaskets: Teflon.
- H. Size and capacity as shown on Drawings.

2.11 POINT-OF-USE PORTABLE POLISHERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. <Insert manufacturer's name>

- C. The system shall be capable of operating from [ordinary tap][pretreated] water.
- D. The unit shall produce purified water that complies with ASTM International, College of American Pathologists, and Clinical Laboratory Standards Institute specifications and USP29-NF24 for [Type I][Type II][Type III] grade water.
- E. Output Flow Rate: [0.44 gpm (2 L/m)]<Insert value>.
- F. Accessories: Inlet shut-off valve.

2.12 ULTRA-VIOLET STERILIZATION UNIT

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. <Insert manufacturer's name>

- C. Inline Sterilizer Light: Provide to reduce the bacteria.
- D. Ultra-Violet Lamps: <Insert number> ultra-violet lamp(s), designed to operate at 115 V, single phase, 60 Hz.
 - 1. Housing: Type 304, electro-polished and passivated stainless steel, complying with MIL-S-5002.
- E. Provide a sensor that will be able to indicate level of UV radiation being produced.

2.13 RECIRCULATING PURE-WATER FAUCET

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1. [WaterSaver Faucet Co]
- 2. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1. [WaterSaver Faucet Co]
- 2. <Insert manufacturer's name>

- C. Faucet:

1. Deck-mounted recirculating type to eliminate dead legs in the purified-water system.
2. Plastic lined.
3. Include diaphragm valve with a brass valve stem and bonnet; on-off control.
4. Compatible with grade of water delivered.

2.14 NON-RECIRCULATING PURE-WATER FAUCET

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Chicago Faucets; Geberit Group]**
 2. **[T&S Brass and Bronze Works, Inc.]**
 3. **[WaterSaver Faucet Co]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Chicago Faucets; Geberit Group]**
 2. **[T&S Brass and Bronze Works, Inc.]**
 3. **[WaterSaver Faucet Co]**
 4. **<Insert manufacturer's name>**
- C. Faucet:
1. Deck-mounted non-recirculating type.
 2. Brass casting and inert polypropylene-lined interior.
 3. Include diaphragm valve with a brass valve stem and bonnet; on-off control.

2.15 SOURCE QUALITY CONTROL

- A. Manufacturer to perform a factory test of components, piping, and skid assemblies prior to shipment and furnish certification that the testing has been performed and the certification meets specified design requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General Locations and Arrangements: Drawings and details indicate general location and arrangement of water piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install seismic restraints on equipment. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- C. Install equipment in accordance with all codes, standards, and manufacturers recommendations.

- D. Provide documentation that the equipment has been installed in accordance with manufacturers requirements.
- E. Provide a startup of the equipment and a per-check of all associated piping, valves, control devices and control panels.
- F. After completion of the installation, provide up to eight hours of instructional time with the Owner's personnel.
- G. Mount equipment and/or skid(s) on concrete pads.
- H. Connect, calibrate, balance, and adjust equipment, devices, and instrumentation to perform functions as specified.

3.2 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of equipment, piping, fittings, and specialties.
- B. Where installing equipment, allow space for service and maintenance.
- C. Connect **[deionized-water][distilled-water][and][RO water]** piping to equipment and service outlets with unions or flanges.

3.3 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 - 1. After installation, Installer shall test equipment for performance, leaks, and defects.
 - 2. The Installer shall notify the **[authorities having jurisdiction][Owner][Architect][and][engineer]**, with at least 24 hours' advance notice.
 - 3. Do not cover equipment or put into service before inspection and approval by the **[authorities having jurisdiction][Owner][Architect][and][engineer]<Insert approval authority>**.
 - 4. Submit separate reports for each test.
- E. Processed-water system will be considered defective if it does not pass tests and inspections.

- F. Prepare test and inspection reports.

3.5 SANITIZING OF EQUIPMENT SERVING HEALTHCARE

- A. Use procedures prescribed by **[authorities having jurisdiction][Owner]** or, if not prescribed, use procedures described below:
1. Cleaning of system as indicated or in accordance with AWWA-C601.
 2. Remove flow indicators and flow measuring devices before flushing. Replace after cleaning is completed.
 3. Sanitize equipment by flushing at a sufficient velocity and quantity to dislodge sediment or dirt with **[reagent][deionized][distilled][and][reverse-osmosis]** water mixture throughout the system.
 4. Opening and closing valves several times collecting samples from various fixtures throughout the system during introduction of chlorine to assure uniform distribution.
 5. After flushing provide evidence of effectiveness of disinfection by filing a report with the **[engineer][Owner][authorities having jurisdiction]**, laboratory reports of bacteriological tests on samples taken from the system. The report shall include the number and locations of where the samples were taken.
 6. If satisfaction is not achieved, repeat the above disinfection process until satisfactory results are obtained. And do not put the system online until this has been obtained.

3.6 SANITIZING OF EQUIPMENT SERVING LABORATORIES

- A. Use procedures prescribed by **[authorities having jurisdiction][Owner]** or, if not prescribed, use procedures described below:
1. Remove flow indicators and flow-measuring devices before flushing. Replace after cleaning is completed.
 2. Clean equipment by pumping at a sufficient velocity and quantity to dislodge sediment or dirt with sodium hypochlorite and a **[deionized-][distilled-][and][RO-]** water mixture throughout the system.
 3. Open all taps until solution is detected, then close taps. Retain solution in the system at least **[three][four]<Insert number>** hours.

END OF SECTION 22 67 00 00



THIS PAGE INTENTIONALLY LEFT BLANK



Task	Specification	Specification Description
22 67 00 00	22 67 13 00	Processed Water Piping for Laboratory and Healthcare Facilities



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 67 13 00 - PROCESSED WATER PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:

1. Plastic pipe and fittings.
2. Glass pipe and fittings.
3. Stainless steel tubing.
4. Stainless steel tube fittings.
5. Transition fittings.
6. CPVC valves.
7. PP valves.
8. PVC valves.
9. PVDF valves.
10. Glass ball valves.
11. Stainless steel ball valves.

B. Services include [reagent-water][deionized-water][distilled-water][and][reverse-osmosis-water].

1.2 DEFINITIONS

A. RO: Reverse osmosis.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product Data: For solvents and adhesives, indicating VOC content.
2. Laboratory Test Reports: For solvents and adhesives, indicating compliance with requirements for low-emitting materials.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: For water piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Welding certificates.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. ASME Compliance: Comply with ASME B31.3 for piping conveying fluid at a pressure of **15 psig (105 kPa)** or greater.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure Ratings:
 - 1. Reagent-Water Piping: **[20 psig (138 kPa)][40 psig (276 kPa)][50 psig (345 kPa)][100 psig (690 kPa)]<Insert pressure>** unless otherwise indicated.
 - 2. Deionized-Water Piping: **[50 psig (345 kPa)][100 psig (690 kPa)][150 psig (1035 kPa)]<Insert pressure>** unless otherwise indicated.
 - 3. Distilled-Water Piping: **[50 psig (345 kPa)][100 psig (690 kPa)][150 psig (1035 kPa)]<Insert pressure>** unless otherwise indicated.
 - 4. RO Water Piping: **[50 psig (345 kPa)][100 psig (690 kPa)][150 psig (1035 kPa)]<Insert pressure>** unless otherwise indicated.
- B. Seismic Performance: Water piping shall withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the piping system will remain in place without separation of any parts when subjected to the seismic forces specified[**and the piping system will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 PLASTIC PIPE AND FITTINGS

- A. Standards: Comply with NSF 14, NSF 61, and NSF 372.
- B. CPVC Pipe and Fittings, Schedule 40: ASTM F441/F441M pipe; with plain ends for solvent-cemented joints and ASTM F438 socket-type fittings.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Asahi/America]**
 - b. **[GF Piping Systems]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Asahi/America]**
- b. **[GF Piping Systems]**
- c. **<Insert manufacturer's name>**

C. CPVC Pipe and Fittings, Schedule 80: ASTM F441/F441M pipe; with plain ends for solvent-cemented joints and ASTM F439 socket-type fittings.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Asahi/America]**
- b. **[GF Piping Systems]**
- c. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Asahi/America]**
- b. **[GF Piping Systems]**
- c. **<Insert manufacturer's name>**

D. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F493.

- 1. Solvent cement shall have a VOC content of 490 g/L or less.
- 2. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- 3. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- 4. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
- 5. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit or 33 mcg/cu. m and that of acetaldehyde shall not exceed 9 mcg/cu. m.

E. PP Pipe and Fittings for Heat-Fusion Joints: Made from ASTM D4101 PP resin.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Asahi/America]**
- b. **[GF Piping Systems: Georg Fischer LLC]**



- c. [IPEX USA LLC]
 - d. [NIBCO INC.]
 - e. [Orion Fittings; A Watts Water Technologies Company]
 - f. [Town & Country Plastics, Inc]
 - g. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Asahi/America]
 - b. [GF Piping Systems: Georg Fischer LLC]
 - c. [IPEX USA LLC]
 - d. [NIBCO INC.]
 - e. [Orion Fittings; A Watts Water Technologies Company]
 - f. [Town & Country Plastics, Inc]
 - g. <Insert manufacturer's name>
- F. PP Pipe and Fittings, Schedule 40: Schedule 40 or SDR 11 dimensions; with socket- or butt-fusion fittings matching pipe dimensions.
- G. PP Pipe and Fittings for Electro-Fusion Joints: Made from ASTM D4101 PP resin.
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [GF Piping Systems: Georg Fischer LLC]
 - b. [IPEX USA LLC]
 - c. [NIBCO INC.]
 - d. [Orion Fittings; A Watts Water Technologies Company]
 - e. [Town & Country Plastics, Inc]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [GF Piping Systems: Georg Fischer LLC]
 - b. [IPEX USA LLC]
 - c. [NIBCO INC.]
 - d. [Orion Fittings; A Watts Water Technologies Company]
 - e. [Town & Country Plastics, Inc]
 - f. <Insert manufacturer's name>
 3. PP Pipe and Fittings, Schedule 80: Schedule 80 or SDR dimensions; with socket fittings matching pipe dimensions.
 4. Electro-Fusion Fitting: Electrical-resistance heating coil for PP piping joints.
- H. PVC Pipe and Fittings, Schedule 40: ASTM D1785 pipe; with plain ends for solvent-cemented joints and ASTM D2466 socket-type fittings.
1. Manufacturers: Subject to compliance with requirements, [provide products by the

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Asahi/America]
- b. [GF Piping Systems]
- c. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Asahi/America]
- b. [GF Piping Systems]
- c. <Insert manufacturer's name>

- I. PVC Pipe and Fittings, Schedule 80: ASTM D1785 pipe; with plain ends for solvent-cemented joints and ASTM D2467 socket-type fittings.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Asahi/America]
- b. [GF Piping Systems]
- c. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Asahi/America]
- b. [GF Piping Systems]
- c. <Insert manufacturer's name>

- J. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer in accordance with ASTM F656.

1. Solvent cement shall have a VOC content of 510 g/L or less.
2. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
3. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
4. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
5. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit or 33 mcg/cu. m and that of acetaldehyde shall not exceed 9 mcg/cu. m.

- K. PVDF Pipe and Fittings: Made from ASTM D3222 PVDF resin.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Asahi/America]**
 - b. **[GF Piping Systems: Georg Fischer LLC]**
 - c. **[NIBCO INC.]**
 - d. **[Orion Fittings; A Watts Water Technologies Company]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Asahi/America]**
 - b. **[GF Piping Systems: Georg Fischer LLC]**
 - c. **[NIBCO INC.]**
 - d. **[Orion Fittings; A Watts Water Technologies Company]**
 - e. **<Insert manufacturer's name>**
 3. PVDF Pipe and Fittings, Schedule 40: Schedule 40 or SDR 11 dimensions; with socket- or butt-fusion fittings matching pipe dimensions.
 4. PVDF Pipe and Fittings, Schedule 80: Pipe made in accordance with ASTM D3222, Schedule 80 or SDR; with socket-fusion fittings matching pipe dimensions.

2.3 GLASS PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Ace Glass, Inc.]**
 2. **[Pegasus Industrial Specialties, Inc.]**
 3. **[QVF]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Ace Glass, Inc.]**
 2. **[Pegasus Industrial Specialties, Inc.]**
 3. **[QVF]**
 4. **<Insert manufacturer's name>**
- C. Glass Pipe and Fittings: Beaded borosilicate glass made for process-piping applications.
- D. Couplings: Stainless steel band type with fluororubber liner, thermoplastic-elastomer seal, and bolt.

2.4 STAINLESS STEEL TUBING

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[LinkPlus USA]**
 2. **[Shaw Stainless & Alloy Piping]**
 3. **[WEBCO Industries]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[LinkPlus USA]**
 2. **[Shaw Stainless & Alloy Piping]**
 3. **[WEBCO Industries]**
 4. **<Insert manufacturer's name>**
- C. Stainless Steel Tube: ASTM A270/A270M, Grade TP304L or TP316L, seamless, sanitary tube of pharmaceutical quality, with wall thickness **[not less than ASTM A312/A312M, Schedule 5]****<Insert wall-thickness data>** unless otherwise indicated; with seamless, stainless steel fittings matching tube thickness and grade, for welded joints.
- D. Stainless Steel Tube Fittings: Fabricated of same material and thickness as tubing for butt welding.
- E. Finish on Inside Surface of Tubes and Fittings: **[Ra 20-micro-inch (Ra 0.5-micro-m) maximum]****<Insert finish>** roughness.
- F. Finish on Outside Surface of Tubes and Fittings: **<Insert finish>**.

2.5 TRANSITION FITTINGS

- A. Couplings, flanges, or other manufactured fittings; same size as, with pressure rating at least equal to, and ends compatible with piping to be joined.

2.6 CPVC VALVES

- A. CPVC Ball Valves:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[GF Piping Systems: Georg Fischer LLC]**
 - e. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - f. **[IPEX USA LLC]**
 - g. **[NIBCO INC.]**

- h. [Plast-O-Matic Valves, Inc]
- i. [Spears Manufacturing Company]
- j. [Thermoplastic Valves, Inc]
- k. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [American Valve, Inc]
- b. [Asahi/America]
- c. [Colonial Engineering, Inc.]
- d. [GF Piping Systems: Georg Fischer LLC]
- e. [Hayward Flow Control; Hayward Industries, Inc.]
- f. [IPEX USA LLC]
- g. [NIBCO INC.]
- h. [Plast-O-Matic Valves, Inc]
- i. [Spears Manufacturing Company]
- j. [Thermoplastic Valves, Inc]
- k. <Insert manufacturer's name>

3. Description:

- a. Standards: Comply with MSS SP-122 and ASTM F1970.
- b. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
- c. Body Material: ASTM D1784 CPVC compound.
- d. Body Design: Union type.
- e. End Connections: Detachable, socket.
- f. Ball: ASTM D1784 CPVC compound.
- g. Port: Full.
- h. Seats: PTFE.
- i. Stem: ASTM D1784 CPVC compound.
- j. Stem Seals: [EPDM][FKM]-rubber O-rings.
- k. Handle: Tee shaped.

B. CPVC Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Colonial Engineering, Inc.]
- b. [GF Piping Systems: Georg Fischer LLC]
- c. [Hayward Flow Control; Hayward Industries, Inc.]
- d. [IPEX USA LLC]
- e. [NIBCO INC.]
- f. [Spears Manufacturing Company]
- g. [Thermoplastic Valves, Inc]
- h. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. [Colonial Engineering, Inc.]
- b. [GF Piping Systems: Georg Fischer LLC]
- c. [Hayward Flow Control; Hayward Industries, Inc.]
- d. [IPEX USA LLC]
- e. [NIBCO INC.]
- f. [Spears Manufacturing Company]
- g. [Thermoplastic Valves, Inc]
- h. <Insert manufacturer's name>

3. Description:

- a. Standard: Comply with ASTM F1970.
- b. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
- c. Body Material: ASTM D1784 CPVC compound.
- d. Body Design: [Lug][or][wafer] type.
- e. Seat: [EPDM][FKM] rubber.
- f. Disc: [ASTM D1784 CPVC compound][ASTM D4101 PP resin]<Insert material>.
- g. Stem: Stainless steel.
- h. Stem Seals: [EPDM][FKM]-rubber O-rings.
- i. Handle: Lever type with locking device.

C. CPVC Ball-Check Valves:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [GF Piping Systems: Georg Fischer LLC]
 - e. [Hayward Flow Control; Hayward Industries, Inc.]
 - f. [IPEX USA LLC]
 - g. [NIBCO INC.]
 - h. [Thermoplastic Valves, Inc]
 - i. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [GF Piping Systems: Georg Fischer LLC]
 - e. [Hayward Flow Control; Hayward Industries, Inc.]
 - f. [IPEX USA LLC]
 - g. [NIBCO INC.]
 - h. [Thermoplastic Valves, Inc]
 - i. <Insert manufacturer's name>

3. Description:

- a. Standard: Comply with ASTM F1970.
- b. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
- c. Body Material: ASTM D1784 CPVC compound.
- d. Body Design: Union type.
- e. End Connections: Detachable, socket.
- f. Ball: ASTM D1784 CPVC compound.
- g. Seat and Seals: [EPDM][or][FKM]-rubber O-rings.

D. CPVC Swing-Check Valves:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Valve, Inc]
 - b. [Spears Manufacturing Company]
 - c. [Thermoplastic Valves, Inc]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Valve, Inc]
 - b. [Spears Manufacturing Company]
 - c. [Thermoplastic Valves, Inc]
 - d. <Insert manufacturer's name>
3. Description:
 - a. Standard: Comply with ASTM F1970.
 - b. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
 - c. Body Material: ASTM D1784 CPVC compound.
 - d. Body Design: Bolted-bonnet type.
 - e. End Connections: Flanged.
 - f. Shaft: ASTM D1784 CPVC compound.
 - g. Disc and Arm: ASTM D1784 CPVC compounds.
 - h. Gasket and Seals: [EPDM][or][FKM] rubber.

E. CPVC Diaphragm Valves:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Asahi/America]
 - b. [Colonial Engineering, Inc.]
 - c. [GF Piping Systems: Georg Fischer LLC]

- d. [Hayward Flow Control; Hayward Industries, Inc.]
 - e. [NIBCO INC.]
 - f. [Spears Manufacturing Company]
 - g. [Thermoplastic Valves, Inc]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Asahi/America]
 - b. [Colonial Engineering, Inc.]
 - c. [GF Piping Systems: Georg Fischer LLC]
 - d. [Hayward Flow Control; Hayward Industries, Inc.]
 - e. [NIBCO INC.]
 - f. [Spears Manufacturing Company]
 - g. [Thermoplastic Valves, Inc]
 - h. <Insert manufacturer's name>
3. Description:
- a. Standard: Comply with ASTM F1970.
 - b. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
 - c. Body Material: ASTM D1784 CPVC compound.
 - d. Body Design: Bolted-bonnet type.
 - e. End Connections for NPS 2 (DN 50) and Smaller: Detachable, socket.
 - f. End Connections for NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Flanged.
 - g. Diaphragm: [EPDM][FKM] rubber.
 - h. Seals: [EPDM][FKM]-rubber O-rings.
 - i. Handle: Wheel type.

2.7 PP VALVES

A. PP Ball Valves:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Asahi/America]
 - b. [GF Piping Systems: Georg Fischer LLC]
 - c. [IPEX USA LLC]
 - d. [NIBCO INC.]
 - e. [Orion Fittings; A Watts Water Technologies Company]
 - f. [Plast-O-Matic Valves, Inc]
 - g. [Thermoplastic Valves, Inc]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Asahi/America]
- b. [GF Piping Systems: Georg Fischer LLC]
- c. [IPEX USA LLC]
- d. [NIBCO INC.]
- e. [Orion Fittings; A Watts Water Technologies Company]
- f. [Plast-O-Matic Valves, Inc]
- g. [Thermoplastic Valves, Inc]
- h. <Insert manufacturer's name>

3. Description:

- a. Standard: MSS SP-122.
- b. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
- c. Body Material: ASTM D4101 PP resin.
- d. Body Design: Union type.
- e. End Connections: Detachable, butt or socket.
- f. Ball: ASTM D4101 PP resin.
- g. Port: Full.
- h. Seats: PTFE.
- i. Stem: ASTM D4101 PP resin.
- j. Stem Seals: FKM-rubber O-rings.
- k. Handle: Tee shaped.

B. PP Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [GF Piping Systems: Georg Fischer LLC]
 - e. [Hayward Flow Control; Hayward Industries, Inc.]
 - f. [IPEX USA LLC]
 - g. [Spears Manufacturing Company]
 - h. [Thermoplastic Valves, Inc]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [GF Piping Systems: Georg Fischer LLC]
 - e. [Hayward Flow Control; Hayward Industries, Inc.]
 - f. [IPEX USA LLC]
 - g. [Spears Manufacturing Company]
 - h. [Thermoplastic Valves, Inc]
 - i. <Insert manufacturer's name>

3. Description:

- a. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
- b. Body Material: ASTM D4101 PP resin.
- c. Body Design: [Lug][or][wafer] type.
- d. Seat: FKM rubber.
- e. Disc: [ASTM D4101 PP resin]<Insert material>.
- f. Stem: Stainless steel.
- g. Stem Seals: FKM-rubber O-rings.
- h. Handle: Lever type with locking device.

C. PP Ball-Check Valves:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [GF Piping Systems: Georg Fischer LLC]
 - d. [Hayward Flow Control; Hayward Industries, Inc.]
 - e. [NIBCO INC.]
 - f. [Thermoplastic Valves, Inc]
 - g. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [GF Piping Systems: Georg Fischer LLC]
 - d. [Hayward Flow Control; Hayward Industries, Inc.]
 - e. [NIBCO INC.]
 - f. [Thermoplastic Valves, Inc]
 - g. <Insert manufacturer's name>
- 3. Description:
 - a. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
 - b. Body Material: ASTM D4101 PP resin.
 - c. Body Design: Union type.
 - d. End Connections: Detachable, socket.
 - e. Ball: ASTM D4101 PP resin.
 - f. Seat and Seals: FKM-rubber O-rings.

D. PP Swing-Check Valves:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Hayward Flow Control; Hayward Industries, Inc.]
 - d. [Spears Manufacturing Company]
 - e. [Thermoplastic Valves, Inc]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Hayward Flow Control; Hayward Industries, Inc.]
 - d. [Spears Manufacturing Company]
 - e. [Thermoplastic Valves, Inc]
 - f. <Insert manufacturer's name>
 3. Description:
 - a. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
 - b. Body Material: ASTM D4101 PP resin.
 - c. Body Design: Bolted-bonnet type.
 - d. End Connections: Flanged.
 - e. Shaft: ASTM D4101 PP resin.
 - f. Disc and Arm: ASTM D4101 PP resin.
 - g. Gasket and Seals: FKM rubber.
- E. PP Diaphragm Valves:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [GF Piping Systems: Georg Fischer LLC]
 - d. [NIBCO INC.]
 - e. [Spears Manufacturing Company]
 - f. [Thermoplastic Valves, Inc]
 - g. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [GF Piping Systems: Georg Fischer LLC]
 - d. [NIBCO INC.]
 - e. [Spears Manufacturing Company]
 - f. [Thermoplastic Valves, Inc]

- g. <Insert manufacturer's name>
- 3. Description:
 - a. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
 - b. Body Material: ASTM D4101 PP resin.
 - c. Body Design: Bolted-bonnet type.
 - d. End Connections for **NPS 2 (DN 50)** and Smaller: Detachable, socket.
 - e. End Connections for **NPS 2-1/2 and NPS 3 (DN 65 and DN 80)**: Flanged.
 - f. Diaphragm: FKM rubber.
 - g. Seals: FKM-rubber O-rings.
 - h. Handle: Wheel type.

2.8 PVC VALVES

A. PVC Ball Valves:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [GF Piping Systems: Georg Fischer LLC]
 - e. [Hayward Flow Control; Hayward Industries, Inc.]
 - f. [IPEX USA LLC]
 - g. [NIBCO INC.]
 - h. [Plast-O-Matic Valves, Inc]
 - i. [Spears Manufacturing Company]
 - j. [Thermoplastic Valves, Inc]
 - k. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [GF Piping Systems: Georg Fischer LLC]
 - e. [Hayward Flow Control; Hayward Industries, Inc.]
 - f. [IPEX USA LLC]
 - g. [NIBCO INC.]
 - h. [Plast-O-Matic Valves, Inc]
 - i. [Spears Manufacturing Company]
 - j. [Thermoplastic Valves, Inc]
 - k. <Insert manufacturer's name>
- 3. Description:
 - a. Standards: Comply with MSS SP-122 and ASTM F1970.

- b. Pressure Rating: **[150 psig (1035 kPa)]<Insert pressure>** at **[73 deg F (23 deg C)]<Insert temperature>**.
- c. Body Material: ASTM D1784 PVC compound.
- d. Body Design: Union type.
- e. End Connections: Detachable, socket.
- f. Ball: ASTM D1784 PVC compound.
- g. Port: Full.
- h. Seats: PTFE.
- i. Stem: ASTM D1784 PVC compound.
- j. Seals: **[EPDM][FKM]**-rubber O-rings.
- k. Handle: Tee shaped.

B. PVC Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[GF Piping Systems: Georg Fischer LLC]**
 - e. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - f. **[NIBCO INC.]**
 - g. **[Spears Manufacturing Company]**
 - h. **[Thermoplastic Valves, Inc]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[GF Piping Systems: Georg Fischer LLC]**
 - e. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - f. **[NIBCO INC.]**
 - g. **[Spears Manufacturing Company]**
 - h. **[Thermoplastic Valves, Inc]**
 - i. **<Insert manufacturer's name>**
3. Description:
 - a. Standard: Comply with ASTM F1970.
 - b. Pressure Rating: **[150 psig (1035 kPa)]<Insert pressure>** at **[73 deg F (23 deg C)]<Insert temperature>**.
 - c. Body Material: ASTM D1784 PVC compound.
 - d. Body Design: **[Lug][or][wafer]** type.
 - e. Seat: **[EPDM][FKM]** rubber.
 - f. Disc: **[ASTM D1784 PVC compound][ASTM D4101 PP resin]<Insert material>**.
 - g. Stem: Stainless steel.
 - h. Stem Seals: **[EPDM][or][FKM]**-rubber O-rings.

- i. Handle: Lever type with locking device.

C. PVC Ball-Check Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[GF Piping Systems: Georg Fischer LLC]**
 - e. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - f. **[IPEX USA LLC]**
 - g. **[NIBCO INC.]**
 - h. **[Thermoplastic Valves, Inc]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[GF Piping Systems: Georg Fischer LLC]**
 - e. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - f. **[IPEX USA LLC]**
 - g. **[NIBCO INC.]**
 - h. **[Thermoplastic Valves, Inc]**
 - i. **<Insert manufacturer's name>**
3. Description:
 - a. Standard: Comply with ASTM F1970.
 - b. Pressure Rating: **[150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>**.
 - c. Body Material: ASTM D1784 PVC compound.
 - d. Body Design: Union type.
 - e. End Connections: Detachable, socket.
 - f. Ball: ASTM D1784 PVC compound.
 - g. Seat and Seals: **[EPDM][or][FKM]**-rubber O-rings.

D. PVC Swing-Check Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - d. **[IPEX USA LLC]**

- e. [Spears Manufacturing Company]
 - f. [Thermoplastic Valves, Inc]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Hayward Flow Control; Hayward Industries, Inc.]
 - d. [IPEX USA LLC]
 - e. [Spears Manufacturing Company]
 - f. [Thermoplastic Valves, Inc]
 - g. <Insert manufacturer's name>
3. Description:
- a. Standard: Comply with ASTM F1970.
 - b. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
 - c. Body Material: ASTM D1784 PVC compound.
 - d. Body Design: Bolted-bonnet type.
 - e. End Connections: Flanged.
 - f. Shaft: ASTM D1784 PVC compound.
 - g. Disc and Arm: ASTM D1784 PVC compounds.
 - h. Gasket and Seals: [EPDM][or][FKM] rubber.

E. PVC Diaphragm Valves:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [GF Piping Systems: Georg Fischer LLC]
 - e. [Hayward Flow Control; Hayward Industries, Inc.]
 - f. [NIBCO INC.]
 - g. [Spears Manufacturing Company]
 - h. [Thermoplastic Valves, Inc]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [GF Piping Systems: Georg Fischer LLC]
 - e. [Hayward Flow Control; Hayward Industries, Inc.]

- f. [NIBCO INC.]
- g. [Spears Manufacturing Company]
- h. [Thermoplastic Valves, Inc]
- i. <Insert manufacturer's name>

3. Description:

- a. Standard: Comply with ASTM F1970.
- b. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
- c. Body Material: ASTM D1784 PVC compound.
- d. Body Design: Bolted-bonnet type.
- e. End Connections for NPS 2 (DN 50) and Smaller: Detachable, socket.
- f. End Connections for NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Flanged.
- g. Diaphragm: [EPDM][FKM] rubber.
- h. Seals: [EPDM][FKM]-rubber O-rings.
- i. Handle: Wheel type.

2.9 PVDF VALVES

A. PVDF Ball Valves:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Asahi/America]
 - b. [GF Piping Systems: Georg Fischer LLC]
 - c. [NIBCO INC.]
 - d. [Orion Fittings; A Watts Water Technologies Company]
 - e. [Plast-O-Matic Valves, Inc]
 - f. [Thermoplastic Valves, Inc]
 - g. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Asahi/America]
 - b. [GF Piping Systems: Georg Fischer LLC]
 - c. [NIBCO INC.]
 - d. [Orion Fittings; A Watts Water Technologies Company]
 - e. [Plast-O-Matic Valves, Inc]
 - f. [Thermoplastic Valves, Inc]
 - g. <Insert manufacturer's name>
- 3. Description:
 - a. Standard: MSS SP-122.
 - b. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
 - c. Body Material: ASTM D3222 PVDF resin.
 - d. Body Design: Union type.

- e. End Connections: Detachable, butt or socket.
- f. Ball: ASTM D3222 PVDF resin.
- g. Port: Full.
- h. Seats: PTFE.
- i. Stem: ASTM D3222 PVDF resin.
- j. Stem Seals: FKM-rubber O-rings.
- k. Handle: Tee shaped.

B. PVDF Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[GF Piping Systems: Georg Fischer LLC]**
 - e. **[Thermoplastic Valves, Inc]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[GF Piping Systems: Georg Fischer LLC]**
 - e. **[Thermoplastic Valves, Inc]**
 - f. **<Insert manufacturer's name>**
3. Description:
 - a. Pressure Rating: **[150 psig (1035 kPa)]<Insert pressure>** at **[73 deg F (23 deg C)]<Insert temperature>**.
 - b. Body Material: ASTM D3222 PVDF resin.
 - c. Body Design: **[Lug][or][wafer]** type.
 - d. Seat: FKM rubber.
 - e. Disc: **[ASTM D3222 PVDF resin]<Insert material>**.
 - f. Stem: Stainless steel.
 - g. Stem Seals: FKM-rubber O-rings.
 - h. Handle: Lever type with locking device.

C. PVDF Ball-Check Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Asahi/America]**
 - b. **[GF Piping Systems: Georg Fischer LLC]**

- c. [NIBCO INC.]
 - d. [Thermoplastic Valves, Inc]
 - e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Asahi/America]
 - b. [GF Piping Systems: Georg Fischer LLC]
 - c. [NIBCO INC.]
 - d. [Thermoplastic Valves, Inc]
 - e. <Insert manufacturer's name>
- 3. Description:
 - a. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
 - b. Body Material: ASTM D3222 PVDF resin.
 - c. Body Design: Union type.
 - d. End Connections: Detachable, socket.
 - e. Ball: ASTM D3222 PVDF resin.
 - f. Seat and Seals: FKM-rubber O-rings.

D. PVDF Swing-Check Valves:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Thermoplastic Valves, Inc]
 - d. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Thermoplastic Valves, Inc]
 - d. <Insert manufacturer's name>
- 3. Description:
 - a. Pressure Rating: [150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
 - b. Body Material: ASTM D3222 PVDF resin.
 - c. Body Design: Bolted-bonnet type.
 - d. End Connections: Flanged.
 - e. Shaft: ASTM D3222 PVDF resin.
 - f. Disc and Arm: ASTM D3222 PVDF resins.
 - g. Gasket and Seals: FKM rubber.

E. PVDF Diaphragm Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[NIBCO INC.]**
 - e. **[Thermoplastic Valves, Inc]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[NIBCO INC.]**
 - e. **[Thermoplastic Valves, Inc]**
 - f. **<Insert manufacturer's name>**
3. Description:
 - a. Pressure Rating: **[150 psig (1035 kPa)]<Insert pressure>** at **[73 deg F (23 deg C)]<Insert temperature>**.
 - b. Body Material: ASTM D3222 PVDF resin.
 - c. Body Design: Bolted-bonnet type.
 - d. End Connections for **NPS 2 (DN 50)** and Smaller: Detachable, socket.
 - e. End Connections for **NPS 2-1/2 and NPS 3 (DN 65 and DN 80)**: Flanged.
 - f. Diaphragm: FKM rubber.
 - g. Seals: FKM-rubber O-rings.
 - h. Handle: Wheel type.

2.10 GLASS BALL VALVES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Andrews Glass Co]**
 2. **[QVF]**
 3. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Andrews Glass Co]**
 2. **[QVF]**
 3. **<Insert manufacturer's name>**

C. Description:

1. Minimum Pressure Rating: **70 psig (483 kPa)**.
2. Body Material: Borosilicate glass with TFE-lined metal flanges.
3. Body Design: Straight-through type.
4. End Connections: Flanged.
5. Ball: Borosilicate glass.
6. Port: Regular.
7. Seats: TFE.
8. Stem: Fused alumina.
9. Stem Seal: TFE.
10. Handle: Lever type.

2.11 STAINLESS STEEL BALL VALVES

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
2. **[Marwin Valve; Richards Industries]**
3. **[Metso Automation USA Inc.]**
4. **[Milwaukee Valve Company]**
5. **[NIBCO INC.]**
6. **[Spirax Sarco Limited]**
7. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
2. **[Marwin Valve; Richards Industries]**
3. **[Metso Automation USA Inc.]**
4. **[Milwaukee Valve Company]**
5. **[NIBCO INC.]**
6. **[Spirax Sarco Limited]**
7. **<Insert manufacturer's name>**

C. Description:

1. Standard: MSS SP-110.
2. Minimum CWP Rating: **1000 psig (6895 kPa)**.
3. Body Material: Stainless steel.
4. Body Design: Three-piece bolted body type.
5. End Connections: Socket welding.
6. Seats: PTFE or TFE.
7. Stem: Stainless steel.
8. Ball: Stainless steel, vented.
9. Port: Full.
10. Handle: Lever type.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING

- A. General Locations and Arrangements: Drawing and details indicate general location and arrangement of water piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for removal of ceiling panel, and coordinate with other services occupying that space.
- F. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- G. Install piping to permit valve servicing.
- H. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure ratings unless otherwise indicated.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220500 "Common Work Results for Plumbing."
- L. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220500 "Common Work Results for Plumbing."
- M. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220500 "Common Work Results for Plumbing."

3.2 JOINT CONSTRUCTION

- A. Where specific joint construction is not indicated, follow piping manufacturer's written instructions.
- B. CPVC Piping Solvent-Cemented Joints: Comply with ASTM F402 for handling solvent cements, primers, and cleaners; make joints in accordance with ASTM D2846/D2846M Appendix.
- C. PP Piping Electro-Fusion Joints: Make in accordance with ASTM F1290.
- D. PP Piping Heat-Fusion Joints: Make in accordance with ASTM D2657.

- E. PVC Piping Solvent-Cemented Joints: Comply with ASTM F402 for handling solvent cements, primers, and cleaners; make joints in accordance with ASTM D2672.
- F. PVDF Piping Heat-Fusion Joints: Make in accordance with ASTM D2657.
- G. Glass Piping Joints: Make with pipe manufacturer's couplings.
- H. Stainless Steel Sanitary Tubing Joints: Make fully penetrated-wall, butt-welding joints without use of filler metal. Comply with AWS D1.6/D1.6M for welding procedures and processes. Polish exterior of welds to match tubing.
- I. Join dissimilar pipe materials with transition fittings compatible with pipe materials being joined.

3.3 INSTALLATION OF VALVES

- A. Install sectional valves close to mains on each branch and riser serving equipment.
- B. Install shutoff valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- C. Locate valves for easy access, and provide separate support where necessary.
- D. Install valves of same size as the pipe or tube in which they are installed unless otherwise indicated.
- E. Install plastic valves of the same material as the plastic pipe in which they are installed.
- F. Install glass valves in glass piping.
- G. Install stainless steel valves in stainless steel tubing.
- H. Install valves in horizontal piping with stem at or above center of pipe.
- I. Install valves in position to allow full movement of stem and lever handle.
- J. Install swing-check valves in horizontal position with the hinge pin level.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Install **[carbon-steel]<Insert material>** pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install **[stainless steel][fiberglass]** pipe hangers for horizontal piping in corrosive environments.
 - 3. Install **[carbon-steel]<Insert material>** pipe support clamps for vertical piping in noncorrosive environments.
 - 4. Install stainless steel pipe support clamps for vertical piping in corrosive environments.
 - 5. Clamps for Vertical Piping: MSS Type 8 or Type 42.
 - 6. Individual, Straight, Horizontal Piping Runs:

- a. **100 Feet (30 m)** and Less: MSS Type 1 adjustable clevis hangers.
 - b. Longer Than **100 Feet (30 m)**: MSS Type 43 adjustable roller hangers.
 - c. Longer Than **100 Feet (30 m)** if Indicated: MSS Type 49 spring cushion rolls.
7. Multiple, Straight, Horizontal Piping Runs, 100 Feet (30 m) or Longer: MSS Type 44 pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52 spring hangers.

- C. Install hangers for stainless steel tubing with the maximum horizontal spacing and minimum rod diameters to comply with MSS SP-58, NFPA 99, locally-enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Install padded hangers for **[CPVC][PP][PVC][PVDF]** piping with maximum horizontal spacing and minimum rod diameters to comply with manufacturer's written recommendations, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Install padded hangers for glass piping with maximum horizontal spacing and minimum rod diameters to comply with MSS SP-58, NFPA 99, manufacturer's written recommendations, locally enforced codes, and authorities having jurisdiction, whichever are most stringent.
- F. Support horizontal piping and tubing within **12 inches (300 mm)** of each fitting[, **valve,**] and coupling.
- G. Support vertical runs of stainless steel piping to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- H. Support vertical runs of **[CPVC][PP][PVC][PVDF]** piping to comply with manufacturer's written recommendations, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- I. Support vertical runs of glass piping to comply with MSS SP-58, manufacturer's written recommendations, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.5 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- C. Connect **[deionized-water][distilled-water][and][RO water]** piping to equipment and service outlets with unions or flanges.

3.6 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency:

1. Owner will engage a qualified testing agency to perform tests and inspections.
2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 1. Test new piping and parts of existing piping that have been altered, extended, or repaired for leaks and defects.
 2. Schedule tests and their inspections by [authorities having jurisdiction][Owner], with at least 24 hours' advance notice.
 3. Do not cover piping or put into service before inspection and approval by the [authorities having jurisdiction][engineer][Owner]<Insert approval authority>.
 4. Test completed piping in accordance with [authorities having jurisdiction][Owner]. If [authorities having jurisdiction do][Owner does] not have published procedures, perform tests as follows:
 - a. Hydrostatic Tests: Test piping at pressure of not less than 1-1/2 times the maximum system operating pressure, but not less than [50 psig (345 kPa)][100 psig (690 kPa)][150 psig (1035 kPa)]<Insert value>. Hold test for [two][four]<Insert number> hours; pressure shall remain constant without pumping. Inspect system to determine visible leaks or significant pressure variations.
 - 1) Exception: Do not subject glass piping to pressure above manufacturer's pressure rating for size.
 5. If piping does not pass the test, replace leaking joints with new materials and retest until no leaks exist.
 6. Submit separate reports for each test.
- E. Processed-water system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.8 CLEANING OF PIPING SERVING HEALTHCARE

- A. Use procedures prescribed by [authorities having jurisdiction][Owner] or, if not prescribed, use procedures described below:
 1. Cleaning of system as indicated or in accordance with AWWA-C601.
 2. Before using, purge new piping and parts of existing piping that have been altered, extended, or repaired.
 3. Remove flow indicators and flow-measuring devices before flushing. Replace after cleaning is completed.
 4. Clean piping by flushing at a sufficient velocity and quantity to dislodge sediment or dirt with [reagent-][deionized-][distilled-][and][RO-] water mixture throughout the system.
 5. After flushing, introduce chlorine or chlorine compound into the system with a dosage sufficient to give an initial residual chlorine content of 50 ppm.
 6. Open and close valves several times to collect samples from various fixtures throughout the system during introduction of chlorine, to assure uniform distribution.
 7. After [12][24]<Insert number>-hour contact period, flush chlorinated water from system.

Processed Water Piping for Laboratory and Healthcare Facilities

8. After flushing, provide evidence of effectiveness of disinfection by filing a report of bacteriological tests on samples taken from the system with the **[engineer][Owner][authorities having jurisdiction]**. The report shall include the number and locations of where the samples were taken.
9. If satisfaction is not achieved, repeat the above disinfection process until satisfactory results are obtained. And do not put the system online until this has been obtained.

3.9 CLEANING OF PIPING SERVING LABORATORIES

- A. Use procedures prescribed by **[authorities having jurisdiction][Owner]** or, if not prescribed, use procedures described below:
 1. Before using, purge new piping and parts of existing piping that have been altered, extended, or repaired.
 2. Remove flow indicators and flow-measuring devices before flushing. Replace after cleaning is completed.
 3. Provide storage tank(s), heat exchanger(s) and pumping system(s) required for cleaning.
 4. Clean piping by pumping at a sufficient velocity and quantity to dislodge sediment or dirt with sodium hypochlorite and **[deionized-][distilled-][and][RO-]** water mixture throughout the system.
 5. Open all taps until cleaning solution is detected, then close taps. Retain solution in the system at least **[three][four]<Insert number>** hours.
- B. At the end of the retention period, open all faucets and taps to thoroughly flush with clean **[reagent-][deionized-][distilled-][and][RO]** water until solution is drained from the system.

3.10 PIPING APPLICATION

- A. Transition and special fittings with pressure ratings at least equal to piping, and of same or compatible material, may be used in applications below.
- B. Pipe fittings shall be the same material as the piping to which it is connected.
- C. Reagent-Water Piping: Use any of the following piping materials for each pipe size range:
 1. Pipe Sizes NPS 3 (DN 80) and Smaller:
 - a. Schedule 40, CPVC pipe and fittings and solvent-cemented joints.
 - b. Schedule 80, CPVC pipe and fittings and solvent-cemented joints.
 - c. PP Pipe and fittings and heat-fusion joints.
 - d. PP pipe and fittings and electro-fusion joints.
 - e. Schedule 40, PVC pipe and fittings and solvent-cemented joints.
 - f. Schedule 80, PVC pipe and fittings and solvent-cemented joints.
 - g. PVDF pipe and fittings and heat-fusion joints.
 - h. Glass pipe and fittings and coupled joints.
 - i. Stainless steel sanitary tubing and welded joints.
- D. Deionized-Water Piping: Use any of the following piping materials for each pipe size range:
 1. NPS 3 (DN 80) and Smaller:
 - a. PP pipe and fittings and heat-fusion joints.

- b. PP Pipe and fittings and electro-fusion joints.
- c. PVDF pipe and fittings and heat-fusion joints.
- d. Glass pipe and fittings and coupled joints.
- e. Stainless Steel Sanitary Tubing and Welded Joints.

E. Distilled-Water Piping: Use any of the following piping materials for each pipe size range:

- 1. NPS 3 (DN 80) and Smaller:
- 2. PP pipe and fittings and heat-fusion joints.
- 3. PP pipe and fittings and electro-fusion joints.
- 4. PVDF pipe and fittings and heat-fusion joints.
- 5. Glass pipe and fittings and coupled joints.
- 6. Stainless steel sanitary tubing and welded joints.

F. Reverse-Osmosis Water Piping: Use any of the following piping materials for each pipe size range:

- 1. NPS 3 (DN 80) and Smaller:
 - a. PP pipe and fittings and heat-fusion joints.
 - b. PP pipe and fittings and electro-fusion joints.
 - c. PVDF pipe and fittings and heat-fusion joints.
 - d. Glass pipe and fittings and coupled joints.
 - e. Stainless steel sanitary tubing and welded joints.

3.11 VALVE SCHEDULE

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
- 1. Valves shall be the same material as the piping to which they are connected.
 - 2. Shutoff Duty: Install ball valves in piping **NPS 2 (DN 50)** and smaller. Install butterfly or diaphragm valves for **NPS 3 (DN 80)** piping.
 - 3. Throttling Duty: Install ball valves in piping **NPS 2 (DN 50)** and smaller. Install diaphragm valves for **NPS 3 (DN 80)** piping.

END OF SECTION 22 67 13 00



THIS PAGE INTENTIONALLY LEFT BLANK



Task	Specification	Specification Description
22 67 13 00	22 67 00 00	Processed Water Equipment for Laboratory and Healthcare Facilities
22 67 13 53	21 05 00 00	Common Work Results for Fire Suppression
22 67 13 53	22 05 00 00	Common Work Results for Plumbing
22 67 13 53	22 13 16 00	Sanitary Waste And Vent Piping
22 67 13 53	22 67 13 00	Processed Water Piping for Laboratory and Healthcare Facilities
22 67 13 53	22 67 00 00	Processed Water Equipment for Laboratory and Healthcare Facilities
22 67 13 53	23 05 00 00	Common Work Results for HVAC



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 01 10 91	23 05 93 00	Testing, Adjusting, and Balancing for HVAC
23 01 20 91	23 05 93 00	Testing, Adjusting, and Balancing for HVAC



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 01 30 51 - EXISTING HVAC AIR DISTRIBUTION SYSTEM CLEANING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes cleaning existing HVAC air-distribution equipment, ducts, plenums, and system components.
- B. Related Requirements:
 - 1. Section 233113.00 "Metal Ducts" for cleaning newly installed metal ducts.
 - 2. Section 233116.00 "Nonmetal Ducts" for cleaning newly installed nonmetal ducts.
 - 3. Section 230593.00 "Testing, Adjusting, Balancing for HVAC" for system flow documentation before cleaning and balancing and following cleaning and restoration.
 - 4. Section 233300.00 "Air Duct Accessories" for restoration of opened ducts and plenums with access doors.

1.2 DEFINITIONS

- A. ACAC: American Council for Accredited Certification.
- B. AIHA-LAP: American Industrial Hygiene Association Lab Accreditation Program
- C. ASCS: Air systems cleaning specialist.
- D. CESB: Council of Engineering and Scientific Specialty Boards.
- E. CMI: Certified Microbial Investigator.
- F. CMC: Certified Microbial Consultant.
- G. CMR: Certified Microbial Remediator.
- H. CMRS: Certified Microbial Remediation Supervisor.
- I. EMLAP: Environmental Microbiology Laboratory Accreditation Program.
- J. IEP: Indoor Environmental Professional.
- K. IICRC: Institute of Inspection, Cleaning, and Restoration Certification.
- L. NADCA: National Air Duct Cleaners Association.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Cleaning agents
 - 2. Antimicrobial surface treatments [("sealant" for sustainable design submittal purposes)].

B. Sustainable Design Submittals:

1. Product Data: For adhesives and sealants, indicating VOC content.
2. Laboratory Test Reports: For adhesives and sealants, indicating compliance with requirements for low-emitting materials.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For an ASCS.
2. For an IEP.
3. For a CMR and a CMRS.

B. Field Quality-Control Reports:

1. Project's existing conditions.
2. Evaluations and recommendations, including cleanliness verification.
3. Strategies and procedures plan.

1.5 CLOSEOUT SUBMITTALS

A. Post-Project report.

1.6 QUALITY ASSURANCE

A. ASCS Qualifications: **[A certified member of NADCA]<Insert objective qualifications>.**

1. Certification: Employ **[an ASCS certified by NADCA on a full-time basis]<Insert objective qualifications>.**
2. Supervisor Qualifications: Certified **[as an ASCS by NADCA]<Insert objective qualifications>.**

B. IEP Qualifications: **[CMI who is certified by ACAC and accredited by CESB][CMC who is certified by ACAC and accredited by CESB].**

C. CMR Qualifications: Certified by ACAC and accredited by CESB.

D. CMRS Qualifications: Certified by ACAC and accredited by CESB.

E. **<Insert objective qualifications for microbial remediation specialist>.**

F. UL Compliance: Comply with UL 181 and UL 181A for fibrous-glass ducts.

G. Cleaning Conference: Conduct conference at **[Project site]<Insert location>.**

1. Review methods and procedures related to HVAC air-distribution system cleaning, including, but not limited to, review of the cleaning strategies and procedures plan.



PART 2 - PRODUCTS

2.1 HVAC CLEANING AGENTS

- A. Manufacturers: Subject to compliance with requirements **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include but are not limited to, the following]**:
1. Apex Engineering Products Corporation.
 2. BBJ Environmental Solutions.
 3. Goodway Technologies Corporation.
 4. Nu-Calgon.
 5. QuestVapco Corporation.
 6. **<Insert manufacturer's name>**.
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- C. Description:
1. Formulated for each specific soiled coil condition that needs remedy.
 2. Will not corrode or tarnish aluminum, copper, or other metals.

2.2 ANTIMICROBIAL SURFACE TREATMENT

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Bio-Cide International, Inc.]**
 2. **[Contec, Inc.]**
 3. **[Ecolab, Inc.]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Bio-Cide International, Inc.]**
 2. **[Contec, Inc.]**
 3. **[Ecolab, Inc.]**
 4. **<Insert manufacturer's name>**
- C. Description: Specific product selected shall be as recommended by the IEP based on the specific antimicrobial needs of the specific Project conditions.
1. Formulated to kill and inhibit growth of microorganisms.
 2. EPA-registered for use in HVAC systems and for the specific application in which it will be used.
 3. Have no residual action after drying, with zero VOC off-gassing.
 4. OSHA compliant.
 5. Treatment shall dry clear to allow continued visual observation of the treated surface.



PART 3 - EXECUTION

3.1 PREPARATION

- A. Inspect HVAC air-distribution equipment, ducts, plenums, and system components to determine appropriate methods, tools, and equipment required for performance of the Work.
- B. Perform "Project Evaluation and Recommendation" according to NADCA ACR.
- C. Cleaning Plan: Prepare a written plan for air-distribution system cleaning that includes strategies and step-by-step procedures. At a minimum, include the following:
 - 1. Supervisor contact information.
 - 2. Work schedule, including location, times, and impact on occupied areas.
 - 3. Methods and materials planned for each HVAC component type.
 - 4. Required support from other trades.
 - 5. Equipment and material storage requirements.
 - 6. Exhaust equipment setup locations.
- D. Existing Conditions Report: Prepare a written report that documents existing conditions of the systems and equipment. Include documentation of existing conditions, including inspection results, photo images, laboratory results, and interpretations of the laboratory results by an IEP.
 - 1. Prepare written report listing conditions detrimental to performance of the Work.
- E. Proceed with work only after conditions detrimental to performance of the Work have been corrected.
- F. Use the existing service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry and for inspection.
- G. Comply with NADCA ACR, "Guidelines for Constructing Service Openings in HVAC Systems" Section.
- H. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning.

3.2 CLEANING

- A. Comply with NADCA ACR, including items identified as "recommended," "advised," and "suggested."
- B. Perform electrical lockout and tagout according to Owner's standards or authorities having jurisdiction.
- C. Remove non-adhered substances and deposits from within the HVAC system.
- D. Complete cleaning in accordance with Owner-Contractor agreed-upon scope of work.
- E. Systems and Components to Be Cleaned:
 - 1. All air-moving and -distribution equipment.
 - 2. Air devices for supply and return air.
 - 3. Air-terminal units and connections.
 - a. VAV boxes.

- b. Chilled beams.
 - c. Fan coil units.
 - d. Unit ventilators.
 - e. Flexible connectors.
 - 4. Ductwork:
 - a. Supply-air ducts, including turning vanes and reheat coils, to the air-handling unit.
 - b. Return-air ducts to the air-handling unit.
 - c. Exhaust-air ducts.
 - d. Transfer ducts.
 - 5. Casings.
 - 6. Duct-mounted coils.
 - 7. Air-Handling Units:
 - a. Interior surfaces of the unit casing.
 - b. Coil surfaces compartment.
 - c. Condensate drain pans.
 - d. Fans, fan blades, and fan housings.
 - 8. Exhaust fans and power ventilators.
 - 9. Filters and filter housings.
 - 10. Gravity ventilators.
 - 11. Air-to-air heat exchangers.
- F. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.
- G. Particulate Collection:
- 1. For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
 - 2. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building,
- H. Control odors and mist vapors during the cleaning and restoration process.
- I. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.
- J. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.
- K. Clean all air-distribution devices, registers, grilles, and diffusers.
- L. Clean non-adhered substance deposits according to NADCA ACR and the following:
- 1. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.
 - 2. Ensure that a suitable operative drainage system is in place prior to beginning wash-down procedures.
 - 3. Clean evaporator coils, reheat coils, and other airstream components.
- M. Air-Distribution Systems:

1. Create service openings in the HVAC system as necessary to accommodate cleaning.
 2. Mechanically clean air-distribution systems specified to remove all visible contaminants, so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR).
- N. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.
- O. Mechanical Cleaning Methodology:
1. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.
 - a. Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
 - b. Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials, such as duct and plenum liners.
 2. Cleaning Mineral-Fiber Insulation Components:
 - a. Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR.
 - b. Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR).
 - c. Fibrous materials that become wet shall be discarded and replaced.
- P. Coil Cleaning:
1. See NADCA ACR, "Coil Surface Cleaning" Section. Type 1, or Type 1 and Type 2, cleaning methods shall be used to render the coil visibly clean and capable of passing coil cleaning verification.
 2. Coil drain pans shall be subject to NADCA ACR, "Non-Porous Surfaces Cleaning Verification." Ensure that condensate drain pans are operational.
 3. Electric-resistance coils shall be de-energized, locked out, and tagged before cleaning.
 4. Cleaning methods shall not cause any appreciable damage to, cause displacement of, inhibit heat transfer, or cause erosion of the coil surface or fins, and shall comply with coil manufacturer's written recommendations.
 5. Rinse thoroughly with clean water to remove any latent residues.
- Q. Application of Antimicrobial Treatment:
1. Apply antimicrobial agents and coatings if active fungal growth is determined by the IEP to be at Condition 2 or Condition 3 status according to IICRC S520, as analyzed by a laboratory **[accredited by AIHA-LAP with an EMLAP certificate]**<Insert alternative accreditation>, and with results interpreted by an IEP. Apply antimicrobial agents and coatings according to manufacturer's written recommendations and EPA registration listing after the removal of surface deposits and debris.
 2. Apply antimicrobial treatments and coatings after the system is rendered clean.

3. Apply antimicrobial agents and coatings directly onto surfaces of interior ductwork.
4. Microbial remediation shall be performed by a **[qualified CMR and CMRS]<Insert alternate qualification>**.

3.3 CLEANLINESS VERIFICATION

- A. Verify cleanliness according to NADCA ACR, "Verification of HVAC System Cleanliness" Section.
- B. Verify HVAC system cleanliness after mechanical cleaning and before applying any treatment or introducing any treatment-related substance to the HVAC system, including biocidal agents and coatings.
- C. Surface-Cleaning Verification: Perform visual inspection for cleanliness. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.
- D. Verification of Coil Cleaning, Known Design Pressure Loss:
 1. Measure static-pressure differential across each coil.
 2. Coil will be considered clean if cleaning restored the coil static-pressure differential within 10 percent of **<Insert inches wg (Pa)>**, the differential measured when the coil was first installed.
- E. Verification of Coil Cleaning, Unknown Design Pressure Loss: Coil will be considered clean if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection.
- F. Additional Verification:
 1. Perform surface comparison testing or NADCA vacuum test.
 2. Conduct NADCA vacuum gravimetric test analysis for nonporous surfaces.
- G. Prepare a written cleanliness verification report. At a minimum, include the following:
 1. Written documentation of the success of the cleaning.
 2. Site inspection reports, initialed by supervisor, including notation on areas of inspection, as verified through visual inspection.
 3. Surface comparison test results if required.
 4. Gravimetric analysis (nonporous surfaces only).
 5. System areas found to be damaged.
- H. Photographic Documentation: Comply with requirements in Section 013233 "Photographic Documentation."

3.4 RESTORATION

- A. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR, "Restoration and Repair of Mechanical Systems" Section.
- B. Restore service openings capable of future reopening. Comply with requirements in **[Section 233113 "Metal Ducts"]****[Section 233116 "Nonmetal Ducts"]**.
- C. Reseal fibrous-glass ducts. Comply with requirements in Section 233116 "Nonmetal Ducts."



- D. Replace fibrous-glass materials that cannot be restored by cleaning or resurfacing. Comply with requirements in Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts."
- E. Replace damaged insulation according to Section 230713 "Duct Insulation."
- F. Ensure that closures do not hinder or alter airflow.
- G. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.
- H. Restore manual volume dampers and air-directional mechanical devices inside the system to their marked position on completion of cleaning.
- I. Measure air flows through air-distribution system.
- J. Measure static-pressure differential across each coil.

3.5 PROJECT CLOSEOUT

- A. Post-Project Report:
 - 1. Post-cleaning laboratory results if any.
 - 2. Post-cleaning photo images.
 - 3. Post-cleaning verification summary.
- B. Drawings:
 - 1. Deviations of existing system from Owner's record drawings.
 - 2. Location of service openings.

END OF SECTION 23 01 30 51



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 01 30 51	23 05 93 00	Testing, Adjusting, and Balancing for HVAC
23 01 30 61	23 31 13 00	Metal Ducts
23 01 50 61	23 21 13 00	Hydronic Piping
23 01 50 61	23 52 23 00	Cast-Iron Boilers
23 01 60 71	23 05 93 00	Testing, Adjusting, and Balancing for HVAC
23 01 60 71	23 62 00 00	Packaged Compressor and Condenser Units



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 05 00 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Motors.
2. Packed expansion joints.
3. Packless expansion joints.
4. Grooved-joint expansion joints.
5. Alignment guides and anchors.
6. Sleeves without waterstop.
7. Sleeves with waterstop.
8. Stack-sleeve fittings.
9. Sleeve-seal systems.
10. Grout.
11. Silicone sealants.
12. Escutcheons.
13. Thermometers, bimetallic actuated.
14. Thermometers, filled system.
15. Thermometers, liquid in glass.
16. Thermometers, light activated.
17. Duct-thermometer mounting brackets.
18. Thermowells.
19. Pressure gauges, dial type.
20. Gauge attachments.
21. Test plugs.
22. Test-plug kits.
23. Sight flow indicators.
24. Flowmeters.
25. Thermal-energy meters.

B. Related Requirements:

1. Section 231123 "Facility Natural-Gas Piping" for gas meters.
2. Section 232216 "Steam and Condensate Piping Specialties" for steam and condensate meters.
3. Section 230923.13 "Energy Meters" for thermal-energy meters connecting with the DDC system.
4. Section 230923.14 "Flow Instruments" for primary flow instruments connecting with the DDC system.

1.2 DEFINITIONS

- A. Existing Piping To Remain:** Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.3 ACTION SUBMITTALS

- A. Product Data:**



1. For each type of product, excluding motors which are included in Part 1 of HVAC equipment Sections.
 - a. Include construction details, material descriptions, and dimensions of individual components, and finishes.
 - b. Include operating characteristics and furnished accessories.
- B. Delegated Design Submittals: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
- C. Sustainable Design Submittals:
 1. Product Data: For sealants, indicating VOC content.
 2. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of meter.
- B. Welding certificates.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of **[expansion joint,][meter,][and][gauge]** to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.
- B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators in accordance with 2021 ASME Boiler and Pressure Vessel Code, Section IX.

1.7 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 1. Motor controllers.



2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 MOTORS

A. Motor Requirements, General:

1. Content includes motors for use on alternating-current power systems of up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.
2. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.
3. Comply with NEMA MG 1 unless otherwise indicated.
4. Comply with IEEE 841 for severe-duty motors.

B. Motor Characteristics:

1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of **3300 ft. (1000 m)** above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Polyphase Motors:

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Premium Efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
 - a. For motors with 2:1 speed ratio, consequent pole, single winding.
 - b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Multispeed Motors, Two Winding: Separate winding for each speed.
6. Rotor: Random-wound, squirrel cage.
7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
8. Temperature Rise: Match insulation rating.
9. Insulation: **[Class F]<Insert class>**.
10. Code Letter Designation:
 - a. Motors 15 Hp and Larger: NEMA starting Code F or Code G.
 - b. Motors Smaller Than 15 Hp: Manufacturer's standard starting characteristic.
11. Enclosure Material: Cast iron for motor frame sizes **[324T]<Insert number>** and larger; rolled steel for motor frame sizes smaller than **[324T]<Insert number>**.

D. Additional Requirements for Polyphase Motors:

1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.



2. Motors Used with Variable-Frequency Controllers: **[Ratings, characteristics, and features coordinated with and approved by controller manufacturer.]**
 - a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time-rise pulses produced by pulse-width-modulated inverters.
 - b. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
3. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

E. Single-Phase Motors:

1. Motors larger than 1/20 hp must be one of the following, to suit starting torque and requirements of specific motor application:
 - a. Permanent-split capacitor.
 - b. Split phase.
 - c. Capacitor start, inductor run.
 - d. Capacitor start, capacitor run.
2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 hp and Smaller: Shaded-pole type.
5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device will automatically reset when motor temperature returns to normal range.

F. Electronically Commutated Motors:

1. Microprocessor-Based Electronic Control Module: Converts **[120 V][or][240 V]** single-phase AC power to three-phase DC power to operate the brushless DC motor.
2. Three-phase power motor module with permanent magnet rotor.
3. **[Circuit board][or][digital speed controller/LED display]**.
4. Building Automation System Interface: Via **[AC voltage signal][DC voltage signal][or][Digital Serial Interface (DSI)]**.

2.2 EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

A. Performance Requirements:

1. Compatibility: Provide products suitable for piping service fluids, materials, working pressures, and temperatures.
2. Capability: Provide products and installations that will accommodate maximum axial movement as scheduled or indicated on Drawings.

B. Packed Expansion Joints:

1. Flexible, Ball-Joint Packed Expansion Joints: **[FBJ-01]<Insert drawing designation>**.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) [Advanced Thermal Systems, Inc]
- 2) [Hyspan Precision Products, Inc]
- 3) [Mason Industries, Inc.]
- 4) <Insert manufacturer's name>

- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) [Advanced Thermal Systems, Inc]
- 2) [Hyspan Precision Products, Inc]
- 3) [Mason Industries, Inc.]
- 4) <Insert manufacturer's name>

- c. Source Limitations: Obtain rubber union connector expansion joints from single manufacturer.
- d. Standards: 2021 ASME Boiler and Pressure Vessel Code: Section II, "Materials"; ASME B31.9 for materials and design of pressure-containing parts and bolting.
- e. Material: Carbon-steel assembly with asbestos-free composition packing.
- f. Design: Provide 360-degree rotation and angular deflection.
- g. Minimum Pressure Rating: [250 psig at 400 deg F (1725 kPa at 204 deg C)]<Insert value>.
- h. Angular Deflection for NPS 6 (DN 150) and Smaller: 30 degrees minimum.
- i. Angular Deflection for NPS 8 (DN 200) and Larger: 15 degrees minimum.
- j. Seal Type: Two carbon-steel and graphite seals suitable for continuous operation at temperature up to 650 deg F (343 deg C).
- k. Internal Ball: Plated with minimum 1-mil chrome cover.
- l. Ball Socket: One- or two-piece design with integral socket/retainer.
- 1) Stuffing Box: Incorporates containment seals and compression seals for containment of injectable packing.
 - 2) Packing Cylinders: Provides packing under full line pressure with check valves to prevent blowback.
- m. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
- n. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

2. Slip-Joint Packed Expansion Joints: [SJ-01]<Insert drawing designation>.

- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) [Adscos Manufacturing LLC]
- 2) [Advanced Thermal Systems, Inc]
- 3) [Hyspan Precision Products, Inc]
- 4) [Metraflex Company (The)]
- 5) <Insert manufacturer's name>

- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of

the following:

- 1) [Adscos Manufacturing LLC]
 - 2) [Advanced Thermal Systems, Inc]
 - 3) [Hyspan Precision Products, Inc]
 - 4) [Metraflex Company (The)]
 - 5) <Insert manufacturer's name>
- c. Source Limitations: Obtain slip-joint packed expansion joints from single manufacturer.
 - d. Standard: ASTM F1007.
 - e. Material: Carbon steel with asbestos-free PTFE packing.
 - f. Design: With internal guide and injection ports for repacking under full system pressure. Housing is to be furnished with drain ports and lifting ring. Include drip connection if used for steam piping.
 - g. Configuration: [Single joint][single joint with base][and][double joint with base] class(es) unless otherwise indicated.
 - h. Slip Tube for Sizes NPS 1-1/2 (DN 40) through NPS 16 (DN 400): Schedule 80.
 - i. Slip Tube for Sizes NPS 18 (DN 450) through NPS 24 (DN 600): Schedule 60.
 - j. Sliding Surface: 2-mil-thick chrome finish.
 - k. End Connections: Flanged or welded ends to match piping system.

C. Packless Expansion Joints:

1. Metal, Compensator Packless Expansion Joints: [MCEJ-01]<Insert drawing designation>.
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Flex-Hose Co., Inc]
 - 2) [Flex-Weld Inc., div of Kelco Industries]
 - 3) [Flex-Weld; a division of Kelco]
 - 4) [Flexicraft Industries]
 - 5) [Hyspan Precision Products, Inc]
 - 6) [Metraflex Company (The)]
 - 7) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Flex-Hose Co., Inc]
 - 2) [Flex-Weld Inc., div of Kelco Industries]
 - 3) [Flex-Weld; a division of Kelco]
 - 4) [Flexicraft Industries]
 - 5) [Hyspan Precision Products, Inc]
 - 6) [Metraflex Company (The)]
 - 7) <Insert manufacturer's name>
 - c. Source Limitations: Obtain metal compensator packless expansion joints from single manufacturer.
 - d. Minimum Pressure Rating: [150 psig (1035 kPa)][175 psig (1200 kPa)][200 psig (1380 kPa)]<Insert value> unless otherwise indicated.
 - e. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid

- flow by an internal pipe sleeve and external housing.
 - f. Joint Axial Movement: **2 inches (50 mm)** of compression and **1/2 inch (12 mm)** of extension.
 - g. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.
 - 1) End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: **[Solder joint][or][threaded]**.
 - 2) End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Threaded.
 - h. Configuration for Steel Piping: Multi-ply, stainless steel bellows; steel-pipe end connections; and carbon-steel shroud.
 - 1) End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
 - 2) End Connections for Steel Pipe NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **[Flanged][Threaded][Welded]**.
- 2. Rubber Union Connector Expansion Joints: **[RUEJ-01]<Insert drawing designation>**.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Amber/Booth Company, Inc.; a VMC Group Company]**
 - 2) **[Flex-Hose Co., Inc]**
 - 3) **[Flo Fab Inc]**
 - 4) **[General Rubber Corporation]**
 - 5) **[Kadant Unaflex, LLC]**
 - 6) **[Metraflex Company (The)]**
 - 7) **[Proco Products, Inc]**
 - 8) **[Unisource Manufacturing, Inc.]**
 - 9) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Amber/Booth Company, Inc.; a VMC Group Company]**
 - 2) **[Flex-Hose Co., Inc]**
 - 3) **[Flo Fab Inc]**
 - 4) **[General Rubber Corporation]**
 - 5) **[Kadant Unaflex, LLC]**
 - 6) **[Metraflex Company (The)]**
 - 7) **[Proco Products, Inc]**
 - 8) **[Unisource Manufacturing, Inc.]**
 - 9) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain rubber union connector expansion joints from single manufacturer.
 - d. Material: Twin reinforced-rubber spheres **[with external restraining cables]**.
 - e. Minimum Pressure Rating: **[150 psig at 170 deg F (1035 kPa at 77 deg C)]<Insert value>** unless otherwise indicated.
 - f. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
 - g. End Connections for Greater than NPS 2 (DN 50): Flanged.

3. Flexible-Hose Packless Expansion Joints: **[FHEJ-01]<Insert drawing designation>**.
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1) **[ASC Engineered Solutions]**
 - 2) **[Flex-Hose Co., Inc]**
 - 3) **[Flex-Pression]**
 - 4) **[Flex-Weld Inc., div of Kelco Industries]**
 - 5) **[Flex-Weld; a division of Kelco]**
 - 6) **[Flexicraft Industries]**
 - 7) **[Kadant Unaflex, LLC]**
 - 8) **[Metraflex Company (The)]**
 - 9) **[Proco Products, Inc]**
 - 10) **[Unisource Manufacturing, Inc.]**
 - 11) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[ASC Engineered Solutions]**
 - 2) **[Flex-Hose Co., Inc]**
 - 3) **[Flex-Pression]**
 - 4) **[Flex-Weld Inc., div of Kelco Industries]**
 - 5) **[Flex-Weld; a division of Kelco]**
 - 6) **[Flexicraft Industries]**
 - 7) **[Kadant Unaflex, LLC]**
 - 8) **[Metraflex Company (The)]**
 - 9) **[Proco Products, Inc]**
 - 10) **[Unisource Manufacturing, Inc.]**
 - 11) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain flexible-hose packless expansion joints from single manufacturer.
- d. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
- e. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
- f. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with **[solder-joint]<Insert type>** end connections.
- 1) Bronze hoses and single-braid bronze sheaths with **450 psig at 70 deg F (3100 kPa at 21 deg C)** and **340 psig at 450 deg F (2340 kPa at 232 deg C)** ratings.
 - 2) Bronze hoses and double-braid bronze sheaths with **700 psig at 70 deg F (4830 kPa at 21 deg C)** and **500 psig at 450 deg F (3450 kPa at 232 deg C)** ratings.
- g. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with **[threaded]<Insert type>** end connections.
- 1) Stainless steel hoses and single-braid, stainless steel sheaths with

- 7) [Flexicraft Industries]
 - 8) [Flo Fab Inc]
 - 9) [Hyspan Precision Products, Inc]
 - 10) [Kadant Unaflex, LLC]
 - 11) [Metraflex Company (The)]
 - 12) [Proco Products, Inc]
 - 13) [Senior Flexonics Pathway]
 - 14) [Tozen Corporation]
 - 15) [U.S. Bellows, Inc.]
 - 16) [Unisource Manufacturing, Inc.]
 - 17) [Universal Hose and Braid; a Hyspan Company]
 - 18) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [Adscos Manufacturing LLC]
 - 2) [Badger Industries, Inc]
 - 3) [Flex-Hose Co., Inc]
 - 4) [Flex-Pression]
 - 5) [Flex-Weld Inc., div of Kelco Industries]
 - 6) [Flex-Weld; a division of Kelco]
 - 7) [Flexicraft Industries]
 - 8) [Flo Fab Inc]
 - 9) [Hyspan Precision Products, Inc]
 - 10) [Kadant Unaflex, LLC]
 - 11) [Metraflex Company (The)]
 - 12) [Proco Products, Inc]
 - 13) [Senior Flexonics Pathway]
 - 14) [Tozen Corporation]
 - 15) [U.S. Bellows, Inc.]
 - 16) [Unisource Manufacturing, Inc.]
 - 17) [Universal Hose and Braid; a Hyspan Company]
 - 18) <Insert manufacturer's name>
- c. Source Limitations: Obtain metal-bellows packless expansion joints from single manufacturer.
- d. Standards: ASTM F1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
- e. Type: Circular, corrugated bellows[with external tie rods].
- f. Minimum Pressure Rating: [150 psig (1035 kPa)][175 psig (1200 kPa)][200 psig (1379 kPa)]<Insert value> unless otherwise indicated.
- g. Configuration: [Single joint][Single joint with base][and][double joint with base] class(es), unless otherwise indicated.
- h. Expansion Joints for Copper Tubing: [Single-][or][multi-]ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
- 1) End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: [Solder joint][or][threaded].
 - 2) End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): [Solder joint][or][threaded].
 - 3) End Connections for Copper Tubing NPS 5 (DN 125) and Larger: Flanged.
- i. Expansion Joints for Steel Piping: [Single-][or][multi-]ply stainless steel bellows, steel pipe

ends, and carbon steel shroud.

- 1) End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
 - 2) End Connections for Steel Pipe NPS 2-1/2 (DN 65) and Larger: **[Flanged][Welded]**.
5. Externally Pressurized Metal-Bellows Packless Expansion Joints: **[EPEJ-01]<Insert drawing designation>**.
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Adscos Manufacturing LLC]**
 - 2) **[Flex-Hose Co., Inc]**
 - 3) **[Flex-Pression]**
 - 4) **[Flex-Weld Inc., div of Kelco Industries]**
 - 5) **[Flex-Weld; a division of Kelco]**
 - 6) **[Flexicraft Industries]**
 - 7) **[Hyspan Precision Products, Inc]**
 - 8) **[Metraflex Company (The)]**
 - 9) **[Senior Flexonics Pathway]**
 - 10) **[Tozen Corporation]**
 - 11) **[U.S. Bellows, Inc.]**
 - 12) **[Unisource Manufacturing, Inc.]**
 - 13) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Adscos Manufacturing LLC]**
 - 2) **[Flex-Hose Co., Inc]**
 - 3) **[Flex-Pression]**
 - 4) **[Flex-Weld Inc., div of Kelco Industries]**
 - 5) **[Flex-Weld; a division of Kelco]**
 - 6) **[Flexicraft Industries]**
 - 7) **[Hyspan Precision Products, Inc]**
 - 8) **[Metraflex Company (The)]**
 - 9) **[Senior Flexonics Pathway]**
 - 10) **[Tozen Corporation]**
 - 11) **[U.S. Bellows, Inc.]**
 - 12) **[Unisource Manufacturing, Inc.]**
 - 13) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain externally pressurized metal-bellows packless expansion joints from single manufacturer.
 - d. Minimum Pressure Rating: **[150 psig (1035 kPa)][200 psig (1379 kPa)][300 psig (2068 kPa)]<Insert value>** unless otherwise indicated.
 - e. Description:
 - 1) Totally enclosed, externally pressurized, multi-ply, stainless steel bellows isolated from fluid flow by an internal pipe sleeve.
 - 2) Carbon-steel housing.
 - 3) Drain plugs and lifting lug for **NPS 3 (DN 80)** and larger.
 - 4) Bellows: With operating clearance between internal pipe sleeves and external

- shrouds.
- 5) Joints: Supplied with a built-in scale to confirm the starting position and operating movement.
- 6) Joint Axial Movement: [4 inches (100 mm)][6 inches (150 mm)][8 inches (200 mm)]<Insert compression limit> of compression and [3/4 inch (19 mm)][1 inch (25 mm)][2 inches (50 mm)]<Insert extension limit> of extension.
- f. Permanent Locking Bolts: Set locking bolts to maintain joint lengths during installation. Temporary welding tabs that are removed after installation in lieu of locking bolts are unacceptable.
- g. End Connection Configuration: Flanged; one raised, fixed and one floating flange.
6. Rubber Packless Expansion Joints: [REJ-01]<Insert drawing designation>.
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Amber/Booth Company, Inc.; a VMC Group Company]
 - 2) [Flex-Hose Co., Inc]
 - 3) [Flex-Weld Inc., div of Kelco Industries]
 - 4) [Flex-Weld; a division of Kelco]
 - 5) [Flexicraft Industries]
 - 6) [Garlock Sealing Technologies]
 - 7) [General Rubber Corporation]
 - 8) [Kadant Unaflex, LLC]
 - 9) [Metraflex Company (The)]
 - 10) [Proco Products, Inc]
 - 11) [Red Valve Company, Inc]
 - 12) [Tozen Corporation]
 - 13) [U.S. Bellows, Inc.]
 - 14) [Unisource Manufacturing, Inc.]
 - 15) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Amber/Booth Company, Inc.; a VMC Group Company]
 - 2) [Flex-Hose Co., Inc]
 - 3) [Flex-Weld Inc., div of Kelco Industries]
 - 4) [Flex-Weld; a division of Kelco]
 - 5) [Flexicraft Industries]
 - 6) [Garlock Sealing Technologies]
 - 7) [General Rubber Corporation]
 - 8) [Kadant Unaflex, LLC]
 - 9) [Metraflex Company (The)]
 - 10) [Proco Products, Inc]
 - 11) [Red Valve Company, Inc]
 - 12) [Tozen Corporation]
 - 13) [U.S. Bellows, Inc.]
 - 14) [Unisource Manufacturing, Inc.]
 - 15) <Insert manufacturer's name>

- c. Source Limitations: Obtain rubber packless expansion joints from single manufacturer.
- d. Standards: ASTM F1123 and FSA's "Expansion Joints - Piping Technical Handbook."
- e. Material: Fabric-reinforced rubber complying with FSA-PSJ-703.
- f. Arch Type: **[Single][or][multiple]** arches **[with external control rods]**.
- g. Spherical Type: **[Single][or][multiple]** spheres **[with external control rods]**.
- h. Minimum Pressure Rating for NPS 1-1/2 to NPS 12 (DN 40 to DN 300): **[225 psig (1551 kPa) at 170 deg F (77 deg C)]<Insert pressure and temperature values>**.
- i. Material for Fluids Containing Acids, Alkalies, or Chemicals: **[Butyl rubber][Chlorosulfonyl-polyethylene rubber][EPDM rubber]<Insert material>**.
- j. Material for Fluids Containing Gas, Hydrocarbons, or Oil: **[Buna-N][Chlorosulfonated polyethylene synthetic rubber]<Insert material>**.
- k. Material for Water: **[Butyl rubber][Buna-N][Chlorosulfonated polyethylene synthetic rubber][Chlorosulfonyl-polyethylene rubber][EPDM rubber][Natural rubber]**.
- l. End Connections: Full-faced, integral steel flanges with steel retaining rings.

D. Grooved-Joint Expansion Joints:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ASC Engineered Solutions]**
 - b. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - c. **[Victaulic Company]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ASC Engineered Solutions]**
 - b. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - c. **[Victaulic Company]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain grooved-joint expansion joints from single manufacturer.
- 4. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
- 5. Standard: AWWA C606, for grooved joints.
- 6. Materials: **[Galvanized,]ASTM A53/A53M, Schedule 40, Type E or S, steel pipe with grooved ends.**
- 7. Couplings: **[Five][Seven][10][12]<Insert number>**, flexible type for steel-pipe dimensions. Include ferrous housing sections **[, Buna-N gasket,][, EPDM rubber gasket,]** and bolts and nuts.

E. Alignment Guides and Anchors:

- 1. Alignment Guides: **[AG-01]<Insert drawing designation>**.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Advanced Thermal Systems, Inc]**
 - 2) **[Amber/Booth Company, Inc.; a VMC Group Company]**

- 3) [ASC Engineered Solutions]
 - 4) [Flex-Hose Co., Inc]
 - 5) [Flex-Pression]
 - 6) [Flex-Weld Inc., div of Kelco Industries]
 - 7) [Flex-Weld; a division of Kelco]
 - 8) [Flexicraft Industries]
 - 9) [Hyspan Precision Products, Inc]
 - 10) [Metraflex Company (The)]
 - 11) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [Advanced Thermal Systems, Inc]
 - 2) [Amber/Booth Company, Inc.; a VMC Group Company]
 - 3) [ASC Engineered Solutions]
 - 4) [Flex-Hose Co., Inc]
 - 5) [Flex-Pression]
 - 6) [Flex-Weld Inc., div of Kelco Industries]
 - 7) [Flex-Weld; a division of Kelco]
 - 8) [Flexicraft Industries]
 - 9) [Hyspan Precision Products, Inc]
 - 10) [Metraflex Company (The)]
 - 11) <Insert manufacturer's name>
- c. Source Limitations: Obtain alignment guides from single manufacturer.
- d. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe. Provide dielectric spacer for use with copper tubing/piping.
2. Anchor Materials:
- a. Steel Shapes and Plates: ASTM A36/A36M.
 - b. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
 - c. Washers: ASTM F844, steel, plain, flat washers.
 - d. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - 1) Stud: Threaded, [zinc-coated carbon][stainless] steel.
 - 2) Expansion Plug: [Zinc-coated carbon][Stainless] steel.
 - 3) Washer and Nut: [Zinc-coated carbon][Stainless] steel.
 - e. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - 1) Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - 2) Stud: ASTM A307, [zinc-coated carbon][stainless] steel with continuous thread on stud, unless otherwise indicated.
 - 3) Washer and Nut: [Zinc-coated carbon][Stainless] steel.

2.3 SLEEVES AND SLEEVE SEALS

A. Sleeves without Waterstop:

1. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron, with plain ends.
2. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.
3. Steel Sheet Sleeves: ASTM A653/A653M, **24 gauge (0.6 mm)** minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.
4. PVC Pipe Sleeves: ASTM D1785, Schedule 40.
5. Molded-PVC Sleeves: With nailing flange.
6. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange.

B. Sleeves with Waterstop:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Advance Products & Systems, LLC]**
 - b. **[CALPICO, Inc.]**
 - c. **[GPT; a division of EnPRO Industries]**
 - d. **[Metraflex Company (The)]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advance Products & Systems, LLC]**
 - b. **[CALPICO, Inc.]**
 - c. **[GPT; a division of EnPRO Industries]**
 - d. **[Metraflex Company (The)]**
 - e. **<Insert manufacturer's name>**
3. Description: Manufactured **[PVC/HDPE][steel][stainless steel][galvanized-steel]**, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.

C. Stack-Sleeve Fittings:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Jay R. Smith Mfg Co; a division of Morris Group International]**
 - b. **[Wade; a subsidiary of McWane Inc.]**
 - c. **[Zurn Industries, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Jay R. Smith Mfg Co; a division of Morris Group International]**
 - b. **[Wade; a subsidiary of McWane Inc.]**
 - c. **[Zurn Industries, LLC]**
 - d. **<Insert manufacturer's name>**
3. Description: Manufactured, **[Dura-coated or Duco-coated][galvanized]** cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
- a. Underdeck Clamp: Clamping ring with setscrews.

D. Sleeve-Seal Systems:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Advance Products & Systems, LLC]**
 - b. **[Airex Manufacturing Inc.]**
 - c. **[CALPICO, Inc.]**
 - d. **[GPT; a division of EnPRO Industries]**
 - e. **[Metraflex Company (The)]**
 - f. **[Proco Products, Inc]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advance Products & Systems, LLC]**
 - b. **[Airex Manufacturing Inc.]**
 - c. **[CALPICO, Inc.]**
 - d. **[GPT; a division of EnPRO Industries]**
 - e. **[Metraflex Company (The)]**
 - f. **[Proco Products, Inc]**
 - g. **<Insert manufacturer's name>**
3. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - a. Hydrostatic seal: **20 psig (137 kPa) minimum).**
 - b. Sealing Elements: **[EPDM-rubber][High-temperature-silicone][Nitrile (Buna-N)]** interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
 - c. Pressure Plates: **[Carbon steel][Composite plastic][Stainless steel][Stainless steel, Type 316].**
 - d. Connecting Bolts and Nuts: **[Carbon steel, with zinc coating. ASTM B633][Stainless steel][Stainless steel, Type 316,]** of length required to secure pressure plates to sealing elements.

E. Grout:

1. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
2. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-

- cement grout.
- 3. Design Mix: **5000 psi (34.5 MPa)**, 28-day compressive strength.
- 4. Packaging: Premixed and factory packaged.

F. Silicone Sealants:

- 1. Silicone Sealant, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[GE Construction Sealants; Momentive Performance Materials Inc.]**
 - 2) **[ITW Polymers Sealants North America]**
 - 3) **[Polymeric Systems, Inc.; PPG Industries, Inc.]**
 - 4) **[Sherwin-Williams Company (The)]**
 - 5) **[Sika Corporation]**
 - 6) **[The Dow Chemical Company]**
 - 7) **[Tremco Incorporated]**
 - 8) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[GE Construction Sealants; Momentive Performance Materials Inc.]**
 - 2) **[ITW Polymers Sealants North America]**
 - 3) **[Polymeric Systems, Inc.; PPG Industries, Inc.]**
 - 4) **[Sherwin-Williams Company (The)]**
 - 5) **[Sika Corporation]**
 - 6) **[The Dow Chemical Company]**
 - 7) **[Tremco Incorporated]**
 - 8) **<Insert manufacturer's name>**
 - c. Standard: ASTM C920, Type S, Grade NS, Class 25, Use NT.
- 2. Silicone Sealant, S, P, T, NT: Single-component, **[25][100/50]**, pourable, **[plus 25 percent and minus 25 percent][plus 100 percent and minus 50 percent]** movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Pecora Corporation]**
 - 2) **[Sika Corporation]**
 - 3) **[The Dow Chemical Company]**
 - 4) **[Tremco Incorporated]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) [Pecora Corporation]
 - 2) [Sika Corporation]
 - 3) [The Dow Chemical Company]
 - 4) [Tremco Incorporated]
 - 5) <Insert manufacturer's name>
- c. Standard: ASTM C920, Type S, Grade P, [Class 25][Class 100/50], Uses T and NT.
3. Silicone Foam Sealant: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Smooth-On]
 - 2) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Smooth-On]
 - 2) <Insert manufacturer's name>
4. Sealant shall have a VOC content of [250]<Insert value> g/L or less.
 - a. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - b. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - c. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - d. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - e. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

2.4 ESCUTCHEONS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [BrassCraft Manufacturing Co.; a Masco company]

2. [Dearborn Brass]
3. [Jones Stephens Corp.]
4. [Keeney Manufacturing Company (The)]
5. [Mid-America Fittings, LLC; A Midland Industries Company]
6. [ProFlo; a Ferguson Enterprises, Inc. brand]
7. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [BrassCraft Manufacturing Co.; a Masco company]
2. [Dearborn Brass]
3. [Jones Stephens Corp.]
4. [Keeney Manufacturing Company (The)]
5. [Mid-America Fittings, LLC; A Midland Industries Company]
6. [ProFlo; a Ferguson Enterprises, Inc. brand]
7. <Insert manufacturer's name>

C. Escutcheon Types:

1. One-Piece, Steel Type: With [polished, chrome-plated][polished brass] finish and setscrew fastener.
2. One-Piece, Stainless Steel Type: With polished stainless steel finish.
3. One-Piece, Cast-Brass Type: With [polished, chrome-plated][polished brass] finish and setscrew fastener.
4. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped [steel][brass] with polished, chrome-plated finish and spring-clip fasteners.
5. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.
6. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; [concealed][and][exposed-rivet] hinge; and spring-clip fasteners.

D. Floor Plates:

1. Split Floor Plates: Steel with concealed hinge.

2.5 METERS AND GAUGES FOR HVAC PIPING

A. Thermometers, Bimetallic Actuated:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ashcroft Inc]
 - b. [Blue Ribbon Corp.]
 - c. [Ernst Flow Industries]
 - d. [Marsh Bellofram]
 - e. [Miljoco Corporation]
 - f. [Noshok]
 - g. [Palmer Wahl Instrumentation Group]
 - h. [REOTEMP Instrument Corporation]
 - i. [Tel-Tru Manufacturing Company]
 - j. [Tserice, H. O. Co]
 - k. [WATTS; A Watts Water Technologies Company]

- l. **[Weiss Instruments, Inc]**
 - m. **[Weksler Glass Thermometer Corp.]**
 - n. **[WIKA Instrument Corporation]**
 - o. **[Winters Instruments - U.S.]**
 - p. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Ashcroft Inc]**
 - b. **[Blue Ribbon Corp.]**
 - c. **[Ernst Flow Industries]**
 - d. **[Marsh Bellofram]**
 - e. **[Miljoco Corporation]**
 - f. **[Noshok]**
 - g. **[Palmer Wahl Instrumentation Group]**
 - h. **[REOTEMP Instrument Corporation]**
 - i. **[Tel-Tru Manufacturing Company]**
 - j. **[Tetric, H. O. Co]**
 - k. **[WATTS; A Watts Water Technologies Company]**
 - l. **[Weiss Instruments, Inc]**
 - m. **[Weksler Glass Thermometer Corp.]**
 - n. **[WIKA Instrument Corporation]**
 - o. **[Winters Instruments - U.S.]**
 - p. **<Insert manufacturer's name>**
3. Source Limitations: Provide bimetallic-actuated thermometers from a single manufacturer.
4. Standard: ASME B40.200.
5. Case: **[Liquid-filled][and][sealed]** type(s); stainless steel with **[3-inch (75-mm)][5-inch (125-mm)]<Insert dimension>** nominal diameter.
6. Dial: **[Nonreflective aluminum]<Insert material>** with permanently etched scale markings and scales in **[deg F (deg C)][deg F and deg C]**.
7. Connector Type(s): Union joint, **[adjustable angle][rigid, back][and][rigid, bottom]<Insert type>**, with unified-inch screw threads.
8. Connector Size: **[1/2 inch (12 mm)]<Insert dimension>**, with ASME B1.1 screw threads.
9. Stem: **0.25 or 0.375 inch (6.4 or 9.5 mm)** in diameter; stainless steel.
10. Window: **[Plain glass][or][plastic]<Insert material>**.
11. Ring: Stainless steel.
12. Element: Bimetal coil.
13. Pointer: Dark-colored metal.
14. Accuracy: Plus or minus **[1][1.5]<Insert number>** percent of scale range.
- B. Thermometers, Filled System - Direct-Mounted, Metal-Case, Vapor-Actuated:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ashcroft Inc]**
 - b. **[Marsh Bellofram]**
 - c. **[Miljoco Corporation]**
 - d. **[Palmer Wahl Instrumentation Group]**
 - e. **[REOTEMP Instrument Corporation]**

- f. [Terice, H. O. Co]
 - g. [Weiss Instruments, Inc]
 - h. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Ashcroft Inc]
 - b. [Marsh Bellofram]
 - c. [Miljoco Corporation]
 - d. [Palmer Wahl Instrumentation Group]
 - e. [REOTEMP Instrument Corporation]
 - f. [Terice, H. O. Co]
 - g. [Weiss Instruments, Inc]
 - h. <Insert manufacturer's name>
 3. Source Limitations: Provide filled-system, direct-mounted, metal-case, vapor-actuated thermometers from a single manufacturer.
 4. Standard: ASME B40.200.
 5. Case: Sealed type, [cast aluminum or drawn steel]<Insert material>; [4-1/2-inch (115-mm)][5-inch (125-mm)][6-inch (150-mm)]<Insert dimension> nominal diameter.
 6. Element: Bourdon tube or other type of pressure element.
 7. Movement: Mechanical,[dampening type,] with link to pressure element and connection to pointer.
 8. Dial: Nonreflective aluminum with permanently etched scale markings graduated in [deg F (deg C)][deg F and deg C].
 9. Pointer: Dark-colored metal.
 10. Window: [Glass][or][plastic]<Insert material>.
 11. Ring: [Metal][Stainless steel]<Insert material>.
 12. Connector Type(s): Union joint, [adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device][rigid, back][and][rigid, bottom]; with ASME B1.1 screw threads.
 13. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
 14. Accuracy: Plus or minus [1]<Insert number> percent of scale range.
- C. Thermometers, Filled System - Direct-Mounted, Plastic-Case, Vapor-Actuated:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ashcroft Inc]
 - b. [Miljoco Corporation]
 - c. [REOTEMP Instrument Corporation]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Ashcroft Inc]**
 - b. **[Miljoco Corporation]**
 - c. **[REOTEMP Instrument Corporation]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Provide filled-system, direct-mounted, plastic-case, vapor-actuated thermometers from single manufacturer.
4. Standard: ASME B40.200.
5. Case: Sealed type, **[plastic]<Insert material>; [4-1/2-inch (115-mm)][5-inch (125-mm)][6-inch (150-mm)]<Insert dimension>** nominal diameter.
6. Element: Bourdon tube or other type of pressure element.
7. Movement: Mechanical, with link to pressure element and connection to pointer.
8. Dial: Nonreflective aluminum with permanently etched scale markings graduated in **[deg F (deg C)][deg F and deg C]**.
9. Pointer: Dark-colored metal.
10. Window: **[Glass][or][plastic]<Insert material>**.
11. Ring: **[Metal][or][plastic]<Insert material>**.
12. Connector Type(s): Union joint, **[adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device][rigid, back][and][rigid, bottom]**; with ASME B1.1 screw threads.
13. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.

14. Accuracy: Plus or minus **[1]<Insert number>** percent of scale range.

D. Thermometers, Filled-System - Remote-Mounted, Metal-Case, Vapor-Actuated:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ametek U.S. Gauge]**
 - b. **[Ashcroft Inc]**
 - c. **[Blue Ribbon Corp.]**
 - d. **[Marsh Bellofram]**
 - e. **[Miljoco Corporation]**
 - f. **[Palmer Wahl Instrumentation Group]**
 - g. **[REOTEMP Instrument Corporation]**
 - h. **[Terice, H. O. Co]**
 - i. **[Weiss Instruments, Inc]**
 - j. **[WIKA Instrument Corporation]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ametek U.S. Gauge]**
 - b. **[Ashcroft Inc]**
 - c. **[Blue Ribbon Corp.]**
 - d. **[Marsh Bellofram]**

- e. [Miljoco Corporation]
 - f. [Palmer Wahl Instrumentation Group]
 - g. [REOTEMP Instrument Corporation]
 - h. [Terice, H. O. Co]
 - i. [Weiss Instruments, Inc]
 - j. [WIKA Instrument Corporation]
 - k. <Insert manufacturer's name>
3. Source Limitations: Provide filled-system, remote-mounted, metal-case, vapor-actuated thermometers from a single manufacturer.
 4. Standard: ASME B40.200.
 5. Case: Sealed type, [cast aluminum or drawn steel]<Insert material>; [4-1/2-inch (115-mm)][6-inch (150-mm)]<Insert dimension> nominal diameter with [back][front] flange and holes for panel mounting.
 6. Element: Bourdon tube or other type of pressure element.
 7. Movement: Mechanical, with link to pressure element and connection to pointer.
 8. Dial: Nonreflective aluminum with permanently etched scale markings graduated in [deg F (deg C)][deg F and deg C].
 9. Pointer: Dark-colored metal.
 10. Window: [Glass][or][plastic]<Insert material>.
 11. Ring: [Metal][Stainless steel]<Insert material>.
 12. Connector Type(s): Union joint, [back][bottom]; with ASME B1.1 screw threads.
 13. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
 14. Accuracy: Plus or minus [1]<Insert number> percent of scale range.
- E. Thermometers, Filled System - Remote-Mounted, Plastic-Case, Vapor-Actuated:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ametek U.S. Gauge]
 - b. [Ashcroft Inc]
 - c. [Miljoco Corporation]
 - d. [REOTEMP Instrument Corporation]
 - e. [Terice, H. O. Co]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Ametek U.S. Gauge]
 - b. [Ashcroft Inc]
 - c. [Miljoco Corporation]
 - d. [REOTEMP Instrument Corporation]
 - e. [Terice, H. O. Co]
 - f. <Insert manufacturer's name>
 3. Source Limitations: Provide filled-system, remote-mounted, plastic-case, vapor-actuated

- thermometers from a single manufacturer.
- 4. Standard: ASME B40.200.
- 5. Case: Sealed type, **[plastic]<Insert material>**; **[4-1/2-inch (115-mm)][6-inch (150-mm)]<Insert dimension>** nominal diameter with **[back][front]** flange and holes for panel mounting.
- 6. Element: Bourdon tube or other type of pressure element.
- 7. Movement: Mechanical, with link to pressure element and connection to pointer.
- 8. Dial: Nonreflective aluminum with permanently etched scale markings graduated in **[deg F (deg C)][deg F and deg C]**.
- 9. Pointer: Dark-colored metal.
- 10. Window: **[Glass][or][plastic]<Insert material>**.
- 11. Ring: **[Metal][or][plastic]<Insert material>**.
- 12. Connector Type(s): Union joint, threaded, **[back][bottom]**; with ASME B1.1 screw threads.
- 13. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

- a. Design for Air-Duct Installation: With ventilated shroud.
- b. Design for Thermowell Installation: Bare stem.

- 14. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

F. Thermometers, Liquid-in-Glass - Metal Case, Compact Style:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Miljoco Corporation]**
 - b. **[Terice, H. O. Co]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Miljoco Corporation]**
 - b. **[Terice, H. O. Co]**
 - c. **<Insert manufacturer's name>**
- 3. Source Limitations: Provide liquid-in-glass, metal-case, compact-style thermometers by single manufacturer.
- 4. Standard: ASME B40.200.
- 5. Case: **[Cast aluminum]<Insert material>**; **6-inch (150-mm)** nominal size.
- 6. Case Form: **[Back angle][Straight]** unless otherwise indicated.
- 7. Tube: Glass with magnifying lens and blue **[or red]** organic liquid.
- 8. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in **[deg F (deg C)][deg F and deg C]**.
- 9. Window: Glass or plastic.
- 10. Stem: Aluminum or brass and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
- 11. Connector: **3/4 inch (19 mm)**, with ASME B1.1 screw threads.

12. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

G. Thermometers, Liquid in Glass - Plastic Case, Compact Style:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Blue Ribbon Corp.]**
 - b. **[Flo Fab Inc]**
 - c. **[Miljoco Corporation]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Weiss Instruments, Inc]**
 - f. **[Weksler Glass Thermometer Corp.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Blue Ribbon Corp.]**
 - b. **[Flo Fab Inc]**
 - c. **[Miljoco Corporation]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Weiss Instruments, Inc]**
 - f. **[Weksler Glass Thermometer Corp.]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Provide liquid-in-glass, plastic-case, compact-style thermometers from single manufacturer.
4. Standard: ASME B40.200.
5. Case: **[Plastic]<Insert material>; 6-inch (150-mm)** nominal size.
6. Case Form: **[Back angle][Straight]** unless otherwise indicated.
7. Tube: Glass with magnifying lens and blue**[or red]** organic liquid.
8. Tube Background: Nonreflective with permanently etched scale markings graduated in **[deg F (deg C)][deg F and deg C]**.
9. Window: Glass or plastic.
10. Stem: Aluminum or brass and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
11. Connector: **3/4 inch (19 mm)**, with ASME B1.1 screw threads.
12. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

H. Thermometers, Liquid in Glass - Metal Case, Industrial Style:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Blue Ribbon Corp.]**

- b. [Flo Fab Inc]
- c. [Miljoco Corporation]
- d. [Palmer Wahl Instrumentation Group]
- e. [Terice, H. O. Co]
- f. [Weiss Instruments, Inc]
- g. [Weksler Glass Thermometer Corp.]
- h. [Winters Instruments - U.S.]
- i. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Blue Ribbon Corp.]
- b. [Flo Fab Inc]
- c. [Miljoco Corporation]
- d. [Palmer Wahl Instrumentation Group]
- e. [Terice, H. O. Co]
- f. [Weiss Instruments, Inc]
- g. [Weksler Glass Thermometer Corp.]
- h. [Winters Instruments - U.S.]
- i. <Insert manufacturer's name>

- 3. Source Limitations: Provide liquid-in-glass, metal-case, industrial-style thermometers from single manufacturer.
- 4. Standard: ASME B40.200.
- 5. Case: [Cast aluminum]<Insert material>; [7-inch (180-mm)][9-inch (230-mm)] nominal size unless otherwise indicated.
- 6. Case Form: [Adjustable angle][Back angle][Straight]<Insert form> unless otherwise indicated.
- 7. Tube: Glass with magnifying lens and blue[or red] organic liquid.
- 8. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in [deg F (deg C)][deg F and deg C].
- 9. Window: [Glass][or][plastic]<Insert material>.
- 10. Stem: [Aluminum]<Insert material> and of length to suit installation.

- a. Design for Air-Duct Installation: With ventilated shroud.
- b. Design for Thermowell Installation: Bare stem.

- 11. Connector: **1-1/4 inches (32 mm)**, with ASME B1.1 screw threads.
- 12. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

I. Thermometers, Liquid in Glass - Plastic Case, Industrial Style:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Ernst Flow Industries]
- b. [Marsh Bellofram]
- c. [Miljoco Corporation]
- d. [Palmer Wahl Instrumentation Group]
- e. [WATTS; A Watts Water Technologies Company]
- f. [Weiss Instruments, Inc]

- g. **[Weksler Glass Thermometer Corp.]**
 - h. **[Winters Instruments - U.S.]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Ernst Flow Industries]**
 - b. **[Marsh Bellofram]**
 - c. **[Miljoco Corporation]**
 - d. **[Palmer Wahl Instrumentation Group]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **[Weiss Instruments, Inc]**
 - g. **[Weksler Glass Thermometer Corp.]**
 - h. **[Winters Instruments - U.S.]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Provide liquid-in-glass, plastic-case, industrial-style thermometers from single manufacturer.
4. Standard: ASME B40.200.
5. Case: **[Plastic]<Insert material>; [7-inch (180-mm)][9-inch (230-mm)]** nominal size unless otherwise indicated.
6. Case Form: **[Adjustable angle][Back angle][Straight]<Insert form>** unless otherwise indicated.
7. Tube: Glass with magnifying lens and blue[**or red**] organic liquid.
8. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in **[deg F (deg C)][deg F and deg C]**.
9. Window: **[Glass][or][plastic]<Insert material>**.
10. Stem: **[Aluminum][Brass][Stainless steel][Aluminum, brass, or stainless steel]<Insert material>** and of length to suit installation.
- a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
11. Connector: **1-1/4 inches (32 mm)**, with ASME B1.1 screw threads.
12. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
- J. Thermometers, Light Activated - Direct Mounted:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Miljoco Corporation]**
 - b. **[Trerice, H. O. Co]**
 - c. **[Weiss Instruments, Inc]**
 - d. **[Weksler Glass Thermometer Corp.]**
 - e. **[Winters Instruments - U.S.]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Miljoco Corporation]**
 - b. **[Terice, H. O. Co]**
 - c. **[Weiss Instruments, Inc]**
 - d. **[Weksler Glass Thermometer Corp.]**
 - e. **[Winters Instruments - U.S.]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Provide light-activated, direct-mounted thermometers from single manufacturer.
 4. Case: **[Plastic][Metal]<Insert material>; [7-inch (180-mm)][9-inch (230-mm)]** nominal size unless otherwise indicated.
 5. Scale(s): **[Deg F (deg C)][Deg F and deg C]**.
 6. Case Form: **[Adjustable angle]<Insert form>**.
 7. Connector: **[1-1/4 inches (32 mm)]<Insert dimension>**, with ASME B1.1 screw threads.
 8. Stem: **[Aluminum]<Insert material>** and of length to suit installation.

- a. Design for Air-Duct Installation: With ventilated shroud.
- b. Design for Thermowell Installation: Bare stem.

9. Display: Digital.
10. Accuracy: Plus or minus **2 deg F (1 deg C)**.

K. Thermometers, Light Activated - Remote Mounted:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Miljoco Corporation]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Miljoco Corporation]**
 - b. **<Insert manufacturer's name>**

3. Source Limitations: Provide light-activated, remote-mounted thermometers from single manufacturer.
4. Case: Plastic, for wall mounting.
5. Scale(s): **[Deg F (deg C)][Deg F and deg C]**.
6. Sensor: Bulb and thermister wire.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
7. Display: Digital.
8. Accuracy: Plus or minus **2 deg F (1 deg C)**.

L. Duct-Thermometer Mounting Brackets:

1. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

M. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: **[CNR][or][CUNI]<Insert material>**.
4. Material for Use with Steel Piping: **[CRES][CSA]<Insert material>**.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: **NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1** pipe threads.
7. Internal Threads: **1/2, 3/4, and 1 inch (13, 19, and 25 mm)**, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
12. Heat-Transfer Medium: **[Mixture of graphite and glycerin]<Insert material>**.

N. Pressure Gauges, Dial Type - Direct Mounted, Metal Case:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ametek U.S. Gauge]**
 - b. **[Ashcroft Inc]**
 - c. **[Blue Ribbon Corp.]**
 - d. **[Ernst Flow Industries]**
 - e. **[Flo Fab Inc]**
 - f. **[Marsh Bellofram]**
 - g. **[Miljoco Corporation]**
 - h. **[Noshok]**
 - i. **[Palmer Wahl Instrumentation Group]**
 - j. **[REOTEMP Instrument Corporation]**
 - k. **[Tel-Tru Manufacturing Company]**
 - l. **[Tetric, H. O. Co]**
 - m. **[WATTS; A Watts Water Technologies Company]**
 - n. **[Weiss Instruments, Inc]**
 - o. **[Weksler Glass Thermometer Corp.]**
 - p. **[WIKI Instrument Corporation]**
 - q. **[Winters Instruments - U.S.]**
 - r. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ametek U.S. Gauge]**
 - b. **[Ashcroft Inc]**
 - c. **[Blue Ribbon Corp.]**
 - d. **[Ernst Flow Industries]**
 - e. **[Flo Fab Inc]**
 - f. **[Marsh Bellofram]**
 - g. **[Miljoco Corporation]**
 - h. **[Noshok]**
 - i. **[Palmer Wahl Instrumentation Group]**

- j. [REOTEMP Instrument Corporation]
 - k. [Tel-Tru Manufacturing Company]
 - l. [Terice, H. O. Co]
 - m. [WATTS; A Watts Water Technologies Company]
 - n. [Weiss Instruments, Inc]
 - o. [Weksler Glass Thermometer Corp.]
 - p. [WIKA Instrument Corporation]
 - q. [Winters Instruments - U.S.]
 - r. <Insert manufacturer's name>
3. Source Limitations: Provide dial-type, direct-mounted, metal-case pressure gauges from single manufacturer.
 4. Standard: ASME B40.100.
 5. Case: [Liquid-filled][Sealed][Open-front, pressure-relief][Solid-front, pressure-relief]<Insert type> type(s); [cast aluminum or drawn steel]<Insert material>; [4-1/2-inch (115-mm)][6-inch (150-mm)]<Insert dimension> nominal diameter.
 6. Pressure-Element Assembly: Bourdon tube.
 7. Pressure Connection: Brass, with [NPS 1/4 (DN 8)][NPS 1/4 or NPS 1/2 (DN 8 or DN 15)][NPS 1/2 (DN 15)], ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 8. Movement: Mechanical, with link to pressure element and connection to pointer.
 9. Dial: Nonreflective aluminum with permanent scale markings graduated in [psi][START_SI] (kPa)][END_SI]psi and kPa].
 10. Pointer: Dark-colored metal.
 11. Window: [Glass][Safety glass][or][acrylic plastic]<Insert material>.
 12. Ring: [Metal][Brass][Stainless steel]<Insert material>.
 13. Accuracy: [Grade A, plus or minus 1 percent of middle half of][Grade B, plus or minus 2 percent of middle half of][Grade C, plus or minus 3 percent of middle half of][Grade D, plus or minus 5 percent of whole] span.

O. Pressure Gauges, Dial Type - Direct Mounted, Plastic Case:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ametek U.S. Gauge]
 - b. [Ashcroft Inc]
 - c. [Flo Fab Inc]
 - d. [Marsh Bellofram]
 - e. [Miljoco Corporation]
 - f. [Noshok]
 - g. [Palmer Wahl Instrumentation Group]
 - h. [REOTEMP Instrument Corporation]
 - i. [Tel-Tru Manufacturing Company]
 - j. [Terice, H. O. Co]
 - k. [Weiss Instruments, Inc]
 - l. [Weksler Glass Thermometer Corp.]
 - m. [WIKA Instrument Corporation]
 - n. [Winters Instruments - U.S.]
 - o. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. [Ametek U.S. Gauge]
 - b. [Ashcroft Inc]
 - c. [Flo Fab Inc]
 - d. [Marsh Bellofram]
 - e. [Miljoco Corporation]
 - f. [Noshok]
 - g. [Palmer Wahl Instrumentation Group]
 - h. [REOTEMP Instrument Corporation]
 - i. [Tel-Tru Manufacturing Company]
 - j. [Terice, H. O. Co]
 - k. [Weiss Instruments, Inc]
 - l. [Weksler Glass Thermometer Corp.]
 - m. [WIKA Instrument Corporation]
 - n. [Winters Instruments - U.S.]
 - o. <Insert manufacturer's name>
3. Source Limitations: Provide dial-type, direct-mounted, plastic-case pressure gauges from a single manufacturer.
 4. Standard: ASME B40.100.
 5. Case: [Sealed]<Insert type> type; [plastic]<Insert material>; [4-1/2-inch (115-mm)][6-inch (150-mm)]<Insert dimension> nominal diameter.
 6. Pressure-Element Assembly: Bourdon tube.
 7. Pressure Connection: Brass, with [NPS 1/4 (DN 8)][NPS 1/4 or NPS 1/2 (DN 8 or DN 15)][NPS 1/2 (DN 15)], ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 8. Movement: Mechanical, with link to pressure element and connection to pointer.
 9. Dial: Nonreflective aluminum with permanent scale markings graduated in [psi (kPa)][psi and kPa].
 10. Pointer: Dark-colored metal.
 11. Window: [Glass][Safety glass][or][acrylic plastic]<Insert material>.
 12. Accuracy: [Grade A, plus or minus 1 percent of middle half of][Grade B, plus or minus 2 percent of middle half of][Grade C, plus or minus 3 percent of middle half of][Grade D, plus or minus 5 percent of whole] span.

P. Pressure Gauges, Dial Type - Remote Mounted, Metal Case:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ametek U.S. Gauge]
 - b. [Ashcroft Inc]
 - c. [Ernst Flow Industries]
 - d. [Flo Fab Inc]
 - e. [Marsh Bellofram]
 - f. [Miljoco Corporation]
 - g. [Noshok]
 - h. [Palmer Wahl Instrumentation Group]
 - i. [REOTEMP Instrument Corporation]
 - j. [Tel-Tru Manufacturing Company]
 - k. [Terice, H. O. Co]
 - l. [WATTS; A Watts Water Technologies Company]
 - m. [Weiss Instruments, Inc]



- n. [WIKA Instrument Corporation]
 - o. [Winters Instruments - U.S.]
 - p. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Ametek U.S. Gauge]
 - b. [Ashcroft Inc]
 - c. [Ernst Flow Industries]
 - d. [Flo Fab Inc]
 - e. [Marsh Bellofram]
 - f. [Miljoco Corporation]
 - g. [Noshok]
 - h. [Palmer Wahl Instrumentation Group]
 - i. [REOTEMP Instrument Corporation]
 - j. [Tel-Tru Manufacturing Company]
 - k. [Trerice, H. O. Co]
 - l. [WATTS; A Watts Water Technologies Company]
 - m. [Weiss Instruments, Inc]
 - n. [WIKA Instrument Corporation]
 - o. [Winters Instruments - U.S.]
 - p. <Insert manufacturer's name>
3. Source Limitations: Provide dial-type, remote-mounted, metal-case pressure gauges from a single manufacturer.
4. Standard: ASME B40.100.
5. Case: [Liquid-filled][Sealed]<Insert type> type; [cast aluminum or drawn steel][metal]<Insert material>; [3-1/2-inch (90-mm)][4-1/2-inch (115-mm)][6-inch (150-mm)]<Insert dimension> nominal diameter with [back][front] flange and holes for panel mounting.
6. Pressure-Element Assembly: Bourdon tube.
7. Pressure Connection: Brass, with [NPS 1/4 (DN 8)][NPS 1/4 or NPS 1/2 (DN 8 or DN 15)][NPS 1/2 (DN 15)], ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
8. Movement: Mechanical, with link to pressure element and connection to pointer.
9. Dial: Nonreflective aluminum with permanent scale markings graduated in [psi (kPa)][psi and kPa].
10. Pointer: Dark-colored metal.
11. Window: [Glass][Safety glass][or][acrylic plastic]<Insert material>.
12. Ring: [Metal][Stainless steel]<Insert material>.
13. Accuracy: [Grade A, plus or minus 1 percent of middle half of][Grade B, plus or minus 2 percent of middle half of][Grade C, plus or minus 3 percent of middle half of][Grade D, plus or minus 5 percent of whole] span.
- Q. Pressure Gauges, Dial Type - Remote Mounted, Plastic Case:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Ashcroft Inc]
 - b. [Flo Fab Inc]
 - c. [Miljoco Corporation]

- d. [Noshok]
 - e. [Palmer Wahl Instrumentation Group]
 - f. [REOTEMP Instrument Corporation]
 - g. [Tel-Tru Manufacturing Company]
 - h. [Tterice, H. O. Co]
 - i. [Weiss Instruments, Inc]
 - j. [WIKA Instrument Corporation]
 - k. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Ashcroft Inc]
 - b. [Flo Fab Inc]
 - c. [Miljoco Corporation]
 - d. [Noshok]
 - e. [Palmer Wahl Instrumentation Group]
 - f. [REOTEMP Instrument Corporation]
 - g. [Tel-Tru Manufacturing Company]
 - h. [Tterice, H. O. Co]
 - i. [Weiss Instruments, Inc]
 - j. [WIKA Instrument Corporation]
 - k. <Insert manufacturer's name>
3. Source Limitations: Provide dial-type, remote-mounted, plastic-case pressure gauges from single manufacturer.
4. Standard: ASME B40.100.
5. Case: [Sealed]<Insert type> type; [plastic]<Insert material>; [3-1/2-inch (90-mm)][4-1/2-inch (115-mm)][6-inch (150-mm)]<Insert dimension> nominal diameter with [back][front] flange and holes for panel mounting.
6. Pressure-Element Assembly: Bourdon tube.
7. Pressure Connection: Brass, with [NPS 1/4 (DN 8)][NPS 1/4 or NPS 1/2 (DN 8 or DN 15)][NPS 1/2 (DN 15)], ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
8. Movement: Mechanical, with link to pressure element and connection to pointer.
9. Dial: Nonreflective aluminum with permanent scale markings graduated in [psi (kPa)][psi and kPa].
10. Pointer: Dark-colored metal.
11. Window: [Glass][Safety glass][or][acrylic plastic]<Insert material>.
12. Accuracy: [Grade A, plus or minus 1 percent of middle half of][Grade B, plus or minus 2 percent of middle half of][Grade C, plus or minus 3 percent of middle half of][Grade D, plus or minus 5 percent of whole] span.
- R. Gauge Attachments:
1. Snubbers: ASME B40.100, brass; with [NPS 1/4 (DN 8)][NPS 1/4 or NPS 1/2 (DN 8 or DN 15)][NPS 1/2 (DN 15)], ASME B1.20.1 pipe threads and [piston][porous-metal]-type surge-dampening device. Include extension for use on insulated piping.
 2. Siphons: Loop-shaped section of [brass][stainless steel][steel] pipe with [NPS 1/4 (DN 8)][NPS 1/4 or NPS 1/2 (DN 8 or DN 15)][NPS 1/2 (DN 15)] pipe threads.
 3. Valves: [Brass ball][Brass or stainless steel needle], with [NPS 1/4 (DN 8)][NPS 1/4 or NPS 1/2 (DN 8 or DN 15)][NPS 1/2 (DN 15)], ASME B1.20.1 pipe threads.
- S. Test Plugs:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[IMI Flow Design, Inc.]**
 - b. **[Miljoco Corporation]**
 - c. **[Nexus Valve, Inc.; Aalberts Hydronic Flow Control]**
 - d. **[Peterson Equipment Co., Inc]**
 - e. **[Tterice, H. O. Co]**
 - f. **[WATTS; A Watts Water Technologies Company]**
 - g. **[Weiss Instruments, Inc]**
 - h. **[Weksler Glass Thermometer Corp.]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[IMI Flow Design, Inc.]**
 - b. **[Miljoco Corporation]**
 - c. **[Nexus Valve, Inc.; Aalberts Hydronic Flow Control]**
 - d. **[Peterson Equipment Co., Inc]**
 - e. **[Tterice, H. O. Co]**
 - f. **[WATTS; A Watts Water Technologies Company]**
 - g. **[Weiss Instruments, Inc]**
 - h. **[Weksler Glass Thermometer Corp.]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Provide test plugs from single manufacturer.
4. Description: Test-station fitting made for insertion in piping tee fitting.
5. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
6. Thread Size: **[NPS 1/4 (DN 8)][or][NPS 1/2 (DN 15)]**, ASME B1.20.1 pipe thread.
7. Minimum Pressure and Temperature Rating: **[500 psig at 200 deg F (3450 kPa at 93 deg C)]<Insert ratings>**.
8. Core Inserts: **[Chlorosulfonated polyethylene synthetic][EPDM]** self-sealing rubber.

T. Test-Plug Kits:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Blue Ribbon Corp.]**
 - b. **[Peterson Equipment Co., Inc]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Blue Ribbon Corp.]**
 - b. **[Peterson Equipment Co., Inc]**

- c. **<Insert manufacturer's name>**
3. Source Limitations: Provide test-plug kits from single manufacturer.
 4. Furnish **[one]<Insert number>** test-plug kit(s) containing **[one][two]** thermometer(s), one pressure gauge and adapter, and carrying case. Thermometer sensing elements, pressure gauge, and adapter probes are to be of diameter to fit test plugs and of length to project into piping.
 5. Low-Range Thermometer: Small, bimetallic insertion type with **[1- to 2-inch- (25- to 50-mm-)]<Insert dimension>** diameter dial and tapered-end sensing element. Dial range is to be at least **[25 to 125 deg F (minus 4 to plus 52 deg C)]<Insert temperature range>**.
 6. High-Range Thermometer: Small, bimetallic insertion type with **[1- to 2-inch- (25- to 50-mm-)]<Insert dimension>** diameter dial and tapered-end sensing element. Dial range is to be at least **[0 to 220 deg F (minus 18 to plus 104 deg C)]<Insert temperature range>**.
 7. Pressure Gauge: Small, Bourdon-tube insertion type with **[2- to 3-inch- (50- to 75-mm-)]<Insert dimension>** diameter dial and probe. Dial range shall be at least **[0 to 200 psig (0 to 1380 kPa)]<Insert range>**.
 8. Carrying Case: Metal or plastic, with formed instrument padding.
- U. Sight Flow Indicators:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ARCHON Industries, Inc]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Ernst Flow Industries]**
 - d. **[John C. Ernst Co., Inc.]**
 - e. **[KOBOLD Instruments, Inc. - USA]**
 - f. **[OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ARCHON Industries, Inc]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Ernst Flow Industries]**
 - d. **[John C. Ernst Co., Inc.]**
 - e. **[KOBOLD Instruments, Inc. - USA]**
 - f. **[OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company]**
 - g. **<Insert manufacturer's name>**
 3. Source Limitations: Provide sight flow indicators from single manufacturer.
 4. Description: Piping inline-installation device for visual verification of flow.
 5. Construction: Bronze or stainless steel body, with sight glass and **[ball, flapper, or paddle wheel]<Insert device>** indicator, and threaded or flanged ends.
 6. Minimum Pressure Rating: **[125 psig (860 kPa)][150 psig (1034 kPa)]<Insert value>**.
 7. Minimum Temperature Rating: **[200 deg F (93 deg C)]<Insert temperature>**.
 8. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
 9. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

V. Flowmeters:

1. Performance Requirements: Manufacturer is to certify that each flowmeter complies with specified performance requirements and characteristics.
2. Flowmeters - Orifice:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[ABB, Process Automation Business]**
 - 2) **[Armstrong International, Inc]**
 - 3) **[Bell & Gossett; a Xylem brand]**
 - 4) **[Meriam Process Technologies]**
 - 5) **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - 6) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[ABB, Process Automation Business]**
 - 2) **[Armstrong International, Inc]**
 - 3) **[Bell & Gossett; a Xylem brand]**
 - 4) **[Meriam Process Technologies]**
 - 5) **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - 6) **<Insert manufacturer's name>**
 - c. Source Limitations: Provide orifice flowmeters from single manufacturer.
 - d. Description: Flowmeter with orifice plate and flanges, differential pressure sensor, hoses or tubing, fittings, valves, indicator, and conversion chart.
 - e. Flow Range: Sensor and indicator are to cover operating range of equipment or system served.
 - f. Orifice Plate: Wafer-orifice-type, calibrated, flow-measuring element; for installation between orifice plate pipe flanges.
 - 1) Design: Differential-pressure-type measurement for **[gas][oil][steam][water]<Insert fluid>**.
 - 2) Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
 - 3) Minimum Pressure Rating: **[300 psig (2070 kPa)]<Insert value>**.
 - 4) Minimum Temperature Rating: **[250 deg F (121 deg C)]<Insert temperature>**.
 - g. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected sensor, and has **6-inch- (150-mm-)** diameter, or equivalent, dial with fittings and copper tubing for connecting to sensor.
 - 1) Scale Divisions: **<Insert value>[gpm|START_SI| (Lps)][gpm and Lps]END_SI**.
 - 2) Accuracy: Plus or minus **[1 percent between 20 and 80 percent of scale range]<Insert accuracy>**.
 - h. Portable Indicators: Handheld, differential-pressure type, calibrated for connected sensor and having two **12 ft. (3.7 m)** hoses, with carrying case.
 - 1) Scale Divisions: **<Insert value>[gpm|START_SI| (Lps)][gpm and Lps]END_SI**.
 - 2) Accuracy: Plus or minus **[2 percent between 20 and 80 percent of scale**

range]<Insert accuracy>.

- i. Display: Shows rate of flow[, **with register to indicate total volume in gallons (liters)**].
 - j. Conversion Chart: Flow rate data compatible with sensor and indicator.
 - k. Operating Instructions: Include complete instructions with each flowmeter.
3. Flowmeters - Pitot Tube:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Armstrong International, Inc]**
 - 2) **[Meriam Process Technologies]**
 - 3) **[Nexus Valve, Inc.; Aalberts Hydronic Flow Control]**
 - 4) **[Preso Meters; Badger Meter Inc.]**
 - 5) **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - 6) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Armstrong International, Inc]**
 - 2) **[Meriam Process Technologies]**
 - 3) **[Nexus Valve, Inc.; Aalberts Hydronic Flow Control]**
 - 4) **[Preso Meters; Badger Meter Inc.]**
 - 5) **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - 6) **<Insert manufacturer's name>**
 - c. Source Limitations: Provide pitot-tube flowmeters from single manufacturer.
 - d. Description: Flowmeter with sensor and indicator.
 - e. Flow Range: Sensor and indicator are to cover operating range of equipment or system served.
 - f. Sensor: Insertion type; for inserting probe in piping and measuring flow directly in **gpm (Lps)**.
 - 1) Design: Differential-pressure-type measurement for **[oil][water]<Insert fluid>**.
 - 2) Construction: Stainless steel probe of length to span inside of pipe, with integral transmitter and direct-reading scale.
 - 3) Fitting for mounting probe in pipe, with **[weld][or][threaded]** connection for attachment to pipe. Provide way to permit removal of probe for service.
 - 4) Minimum Pressure Rating: **[150 psig (1035 kPa)]<Insert value>**.
 - 5) Minimum Temperature Rating: **[250 deg F (121 deg C)]<Insert temperature>**.
 - g. Indicator: Handheld meter; either an integral part of sensor or a separate meter.
 - h. Integral Transformer: For low-voltage power connection.
 - i. Accuracy: Plus or minus **[3]<Insert number>** percent.
 - j. Display: Shows rate of flow[, **with register to indicate total volume in gallons (liters)**].
 - k. Operating Instructions: Include complete instructions with each flowmeter.
4. Flowmeters - Turbine:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) [ERDCO Engineering Corp]
- 2) [Hoffer Flow Controls, Inc]
- 3) [ONICON Incorporated]
- 4) [Preso Meters; Badger Meter Inc.]
- 5) [SeaMetrics, Inc.]
- 6) [Spirax Sarco Limited]
- 7) [Veris Industries]
- 8) <Insert manufacturer's name>

- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) [ERDCO Engineering Corp]
- 2) [Hoffer Flow Controls, Inc]
- 3) [ONICON Incorporated]
- 4) [Preso Meters; Badger Meter Inc.]
- 5) [SeaMetrics, Inc.]
- 6) [Spirax Sarco Limited]
- 7) [Veris Industries]
- 8) <Insert manufacturer's name>

- c. Source Limitations: Provide turbine flowmeters from single manufacturer.
d. Description: Flowmeter with sensor and indicator.
e. Flow Range: Sensor and indicator are to cover operating range of equipment or system served.
f. Sensor: Impeller turbine; for inserting in pipe fitting or for installing in piping and measuring flow directly in **gpm (Lps)**.

- 1) Design: Device or pipe fitting with inline turbine and integral direct-reading scale for **[gas][oil][steam][water]<Insert fluid>**.
- 2) Construction: Bronze or stainless steel body, with plastic turbine or impeller.
- 3) Fitting for mounting probe in pipe, with **[weld][or][threaded]** connection for attachment to pipe. Provide way to permit removal of probe for service.
- 4) Minimum Pressure Rating: **[150 psig (1035 kPa)]<Insert value>**.
- 5) Minimum Temperature Rating: **[180 deg F (82 deg C)]<Insert temperature>**.

- g. Indicator: Handheld meter; either an integral part of sensor or a separate meter.
h. Accuracy: Plus or minus **[1-1/2]<Insert number>** percent.
i. Display: Shows rate of flow[, **with register to indicate total volume in gallons (liters)**].
j. Operating Instructions: Include complete instructions with each flowmeter.

5. Flowmeters - Venturi:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) [Armstrong International, Inc]
- 2) [Gerand Engineering Co]
- 3) [Hyspan Precision Products, Inc]

- 4) [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - 5) [Preso Meters; Badger Meter Inc.]
 - 6) [Rosemount; Emerson Electric Co., Automation Solutions]
 - 7) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [Armstrong International, Inc]
 - 2) [Gerand Engineering Co]
 - 3) [Hyspan Precision Products, Inc]
 - 4) [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - 5) [Preso Meters; Badger Meter Inc.]
 - 6) [Rosemount; Emerson Electric Co., Automation Solutions]
 - 7) <Insert manufacturer's name>
- c. Source Limitations: Provide venture flowmeters from single manufacturer.
- d. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
- e. Flow Range: Sensor and indicator are to cover operating range of equipment or system served.
- f. Flow-Measuring Element:
- 1) Design: Differential-pressure-type measurement for [gas][oil][steam][water]<Insert fluid>.
 - 2) Venturi type with [in-line][or][insertion] element.
 - 3) Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
 - 4) Minimum Pressure Rating: [250 psig (1725 kPa)]<Insert value>.
 - 5) Minimum Temperature Rating: [250 deg F (121 deg C)]<Insert temperature>.
 - 6) End Connections for NPS 2 (DN 50) and Smaller: Threaded.
 - 7) End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged or welded.
 - 8) Flow Range: Flow-measuring element and flowmeter are to cover operating range of equipment or system served.
- g. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and has **6-inch- (150-mm-)** diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
- 1) Scale: <Insert value> gpm (Lps).
 - 2) Accuracy: Plus or minus [1 percent between 20 and 80 percent of scale range]<Insert accuracy>.
- h. Portable Indicators: Handheld, differential-pressure type, calibrated for connected flowmeter element and has two **12 ft. (3.7 m)** hoses, with carrying case.
- 1) Scale: <Insert value> gpm (Lps).
 - 2) Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.
- i. Display: Shows rate of flow[, **with register to indicate total volume in gallons (liters)**].
- j. Conversion Chart: Flow rate data compatible with sensor.
- k. Operating Instructions: Include complete instructions with each flowmeter.
6. Flowmeters - Vortex Shedding:

-
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1) **[ABB, Process Automation Business]**
 - 2) **[Endress+Hauser]**
 - 3) **[ISTEC Corporation]**
 - 4) **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - 5) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[ABB, Process Automation Business]**
 - 2) **[Endress+Hauser]**
 - 3) **[ISTEC Corporation]**
 - 4) **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - 5) **<Insert manufacturer's name>**
- c. Source Limitations: Provide vortex-shedding flowmeters from single manufacturer.
- d. Description: Flowmeter with sensor and indicator.
- e. Flow Range: Sensor and indicator are to cover operating range of equipment or system served.
- f. Sensor: Inline type; for installing between pipe flanges and measuring flow directly in **gpm (Lps)**.
- 1) Design: Flow-obstruction device, vortex-measurement type for **[gas][steam][and][liquids]**.
 - 2) Construction: Stainless steel body, with integral transmitter and direct-reading scale.
 - 3) Minimum Pressure Rating: **[1000 psig (6900 kPa)]<Insert value>**.
 - 4) Minimum Temperature Rating: **[500 deg F (260 deg C)]<Insert temperature>**.
 - 5) Integral Transformer: For low-voltage power operation.
- g. Indicator: Handheld meter; either an integral part of sensor or a separate meter.
- h. Accuracy: Plus or minus **[0.25]<Insert number>** percent for liquids and **[0.75]<Insert number>** percent for gases.
- i. Display: Shows rate of flow[, **with register to indicate total volume in gallons (liters)**].
- j. Operating Instructions: Include complete instructions with each flowmeter.
7. Thermal-Energy Meters - Turbine:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1) **[ISTEC Corporation]**
 - 2) **[ONICON Incorporated]**
 - 3) **[Preso Meters; Badger Meter Inc.]**
 - 4) **[Veris Industries]**
 - 5) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) [ISTEC Corporation]
- 2) [ONICON Incorporated]
- 3) [Preso Meters; Badger Meter Inc.]
- 4) [Veris Industries]
- 5) <Insert manufacturer's name>

- c. Source Limitations: Provide turbine thermal-energy meters from single manufacturer.
- d. Performance Requirements: Manufacturer is to certify that each flowmeter complies with specified performance requirements and characteristics.
- e. Description: System with[**strainer**,] flow sensor, two temperature sensors, transmitter, indicator, and connecting wiring.
- f. Flow Sensor: Turbine type; for inserting in pipe fitting or for installing in piping and measuring flow directly in **gpm (Lps)**.
 - 1) Design: Device or pipe fitting with inline turbine and integral direct-reading scale for **[gas][oil][steam][water]**.
 - 2) Construction: Bronze or stainless steel body, with plastic turbine or impeller.
 - 3) Fitting for mounting probe in pipe, with **[weld][or][threaded]** connection for attachment to pipe. Provision to remove probe for service.
 - 4) Minimum Pressure Rating: **[150 psig (1035 kPa)]<Insert value>**.
 - 5) Minimum Temperature Rating: **[180 deg F (82 deg C)]<Insert temperature>**.
- g. Temperature Sensors: Insertion-type sensor-transducer.
- h. Indicator: Solid-state, integrating-type meter[**with integral battery pack**]; for wall mounting.
 - 1) Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or **British thermal units (joules)**.
 - 2) Battery Pack: Five-year lithium battery.
- i. Accuracy: Plus or minus **[1]<Insert number>** percent.
- j. Display: Visually indicates total fluid volume in **gallons (liters)** and thermal-energy flow in kilowatts per hour or **British thermal units (joules)**.
- k. Strainer: Full size of main line piping.
- l. Operating Instructions: Include complete instructions with each thermal-energy meter system.

8. Thermal-Energy Meters - Ultrasonic:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) [Armstrong International, Inc]
 - 2) [Badger Meter, Inc.]
 - 3) [ONICON Incorporated]
 - 4) [Preso Meters; Badger Meter Inc.]
 - 5) [Siemens Industry, Inc., Energy Management Division]
 - 6) [Veris Industries]
 - 7) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert



manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) **[Armstrong International, Inc]**
 - 2) **[Badger Meter, Inc.]**
 - 3) **[ONICON Incorporated]**
 - 4) **[Preso Meters; Badger Meter Inc.]**
 - 5) **[Siemens Industry, Inc., Energy Management Division]**
 - 6) **[Veris Industries]**
 - 7) **<Insert manufacturer's name>**
- c. Source Limitations: Provide ultrasonic thermal-energy meters from single manufacturer.
- d. Performance Requirements: Manufacturer is to certify that each flowmeter complies with specified performance requirements and characteristics.
- e. Description: Meter with flow sensor, two temperature sensors, transmitter, indicator, and connecting wiring.
- f. Flow Sensor: Transit-time ultrasonic type with transmitter.
- g. Temperature Sensors: Insertion-type or strap-on transducer.
- h. Indicator: Solid-state, integrating-type meter[**with integral battery pack**].
- 1) Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or **British thermal units (joules)**.
 - 2) Battery Pack: Five-year lithium battery.
- i. Accuracy: Plus or minus **[1]<Insert number>** percent.
- j. Display: Visually indicates total fluid volume in **gallons (liters)** and thermal-energy flow in kilowatts per hour or **British thermal units (joules)**.
- k. Operating Instructions: Include complete instructions with each thermal-energy meter system.

PART 3 - EXECUTION

3.1 INSTALLATION OF EXPANSION JOINTS - GENERAL

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.

3.2 INSTALLATION OF PACKED EXPANSION JOINTS

- A. Install packed expansion joints with packing suitable for fluid service.

3.3 INSTALLATION OF PACKLESS EXPANSION JOINTS

- A. Install metal-bellows packless expansion joints in accordance with EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
- B. Install rubber packless expansion joints in accordance with FSA-PSJ-703.

3.4 INSTALLATION OF GROOVED-JOINT EXPANSION JOINTS

- A. Install grooved-joint expansion joints to grooved-end steel piping.

3.5 INSTALLATION OF ALIGNMENT GUIDES AND ANCHORS

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install **[one][two]** guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than **[four]<Insert number>** pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9.
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-58, Type 24; U bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
 - 3. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

3.6 INSTALLATION OF PIPE LOOPS AND SWING CONNECTIONS

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- B. Connect risers and branch connections to mains with at least **[five]<Insert number>** pipe fittings, including tee in main.
- C. Connect risers and branch connections to terminal units with at least **[four]<Insert number>** pipe fittings, including tee in riser.
- D. Connect mains and branch connections to terminal units with at least **[four]<Insert number>** pipe fittings, including tee in main.

3.7 INSTALLATION OF SLEEVES - GENERAL

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide **[1-inch (25-mm)][2-inch (50-mm)]<Insert dimension>** annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.
 - C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas **[2 inches (50 mm)]<Insert dimension>** above finished floor level.
 3. Using **[grout][or][silicone sealant]**, seal space outside of sleeves in floors/slabs/walls without sleeve-seal system. Select to maintain fire resistance of floor/slab/wall.
 - D. Install sleeves for pipes passing through interior partitions.
 1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide **1/4-inch (6.4-mm)** annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants that joint sealant manufacturer's literature indicates is appropriate for size, depth, and location of joint.
 - E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."
- ### 3.8 INSTALLATION OF SLEEVES WITH WATERSTOP
- A. Install sleeve with waterstop as new walls and slabs are constructed.
 - B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange centered across width of concrete slab or wall.
 - C. Secure nailing flanges to wooden concrete forms.
 - D. Using **[grout][or][silicone sealant]**, seal space around outside of sleeves.
- ### 3.9 INSTALLATION OF STACK-SLEEVE FITTINGS
- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 1. Install fittings that are large enough to provide **1/4-inch (6.4-mm)** annular clear space between sleeve and pipe or pipe insulation.
 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
 3. Install section of cast-iron soil pipe to extend sleeve to **3 inches (76 mm)** above finished floor level.
 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 5. Using silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

- B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.10 INSTALLATION OF SLEEVE-SEAL SYSTEMS

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building, and passing through exterior walls.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.11 INSTALLATION OF ESCUTCHEONS

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

3.12 INSTALLATION OF METERS AND GAUGES

- A. Install thermowells with socket extending **[a minimum of 2 inches (50 mm) into fluid][one-third of pipe diameter][to center of pipe]** and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing, and support tubing to prevent kinks. Use minimum tubing length.
- G. Install pipe-mounted thermal-energy temperature sensors in thermowells and extend wiring to indicator.
- H. Install duct-thermometer-mounting brackets in walls of ducts. Attach to duct with screws.
- I. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.
- J. Install remote-mounted pressure gauges on panel.
- K. Install valve and snubber in piping for each pressure gauge for fluids (except steam).
- L. Install valve and syphon fitting in piping for each pressure gauge for steam.

- M. Install test plugs in piping tees.
- N. Install flow indicators in piping systems in accessible positions for easy viewing.
- O. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
- P. Install flowmeter elements in accessible positions in piping systems.
- Q. Install wafer-orifice flowmeter elements between orifice-type pipe flanges.
- R. Install all flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.
- S. Install permanent indicators on walls or brackets in accessible and readable positions.
- T. Install connection fittings in accessible locations for attachment to portable indicators.
- U. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.
- V. Install thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler.
 - 3. Two inlets and two outlets of each chiller.
 - 4. Inlet and outlet of each hydronic coil in air-handling units.
 - 5. Two inlets and two outlets of each hydronic heat exchanger.
 - 6. Inlet and outlet of each thermal-storage tank.
 - 7. Outside-, return-, supply-, and mixed-air ducts.
 - 8. **<Insert location>**.
- W. Install pressure gauges in the following locations:
 - 1. Discharge of each pressure-reducing valve.
 - 2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
 - 3. Suction and discharge of each pump.
 - 4. **<Insert location>**.

3.13 CONNECTIONS

- A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.
- B. Connect flowmeter-system elements to meters.
- C. Connect flowmeter transmitters to meters.
- D. Connect thermal-energy meter transmitters to meters.

3.14 ADJUSTING

- A. After installation, calibrate meters according to manufacturer's written instructions.

- B. Adjust faces of meters and gauges to proper angle for best visibility.

3.15 FIELD QUALITY CONTROL

- A. Sleeves and Sleeve Seals:

- 1. Perform the following tests and inspections:
 - a. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
 - b. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.
- 2. Prepare test and inspection reports.

- B. Escutcheons:

- 1. Using new materials, replace broken and damaged escutcheons and floor plates.

3.16 SLEEVES APPLICATION

- A. Use sleeves and sleeve seals for the following piping-penetration applications:

- 1. Exterior Concrete Walls above and below Grade:
 - a. Sleeves with waterstops.
 - 1) Select sleeve size to allow for **[1-inch (25-mm)]<Insert dimension>** annular clear space between piping and sleeve for installing sleeve-seal system.
- 2. Concrete Slabs-on-Grade:
 - a. Sleeves with waterstops.
 - 1) Select sleeve size to allow for **[1-inch (25-mm)]<Insert dimension>** annular clear space between piping and sleeve for installing sleeve-seal system.
- 3. Concrete Slabs above Grade:
 - a. **[Sleeves with waterstops][or][stack-sleeve fittings]**.
- 4. Interior Walls and Partitions:
 - a. Sleeves without waterstops.

3.17 ESCUTCHEONS APPLICATION

- A. Escutcheons for New Piping and Relocated Existing Piping:

- 1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
- 2. Chrome-Plated Piping: One piece, **[steel][cast brass][or split-plate steel]** with polished, chrome-plated finish.

3. Insulated Piping:
 - a. One piece, steel with **[polished, chrome-plated][polished brass]** finish.
 - b. One piece, stainless steel with polished stainless steel finish.
 - c. One piece, cast brass with **[polished, chrome-plated][polished brass]** finish.
 - d. One piece, stamped steel **[or split plate, stamped steel with concealed hinge][or split plate, stamped steel with exposed-rivet hinge]** with polished, chrome-plated finish.
4. Bare Piping at Wall and Floor Penetrations in Finished Spaces:
 - a. One piece, steel with **[polished, chrome-plated][polished brass]** finish.
 - b. One piece, stainless steel with polished stainless steel finish.
 - c. One piece, cast brass with **[polished, chrome-plated][polished brass]** finish.
 - d. One piece, stamped steel **[or split plate, stamped steel with concealed hinge][or split plate, stamped steel with exposed-rivet hinge]** with polished, chrome-plated finish.
5. Bare Piping at Ceiling Penetrations in Finished Spaces:
 - a. One piece, steel with **[polished, chrome-plated][polished brass]** finish.
 - b. One piece, stainless steel with polished stainless steel finish.
 - c. One piece, cast brass with **[polished, chrome-plated][polished brass]** finish.
 - d. One piece, stamped steel **[or split plate, stamped steel with concealed hinge][or split plate, stamped steel with exposed-rivet hinge]** with polished, chrome-plated finish.
6. Bare Piping in Unfinished Service Spaces:
 - a. One piece, steel with polished, chrome-plated finish.
 - b. One piece, cast brass with **[polished, chrome-plated][rough-brass]** finish.
 - c. One piece, stamped steel **[or split plate, stamped steel with concealed hinge][or split plate, stamped steel with exposed-rivet hinge]** with polished, chrome-plated finish.
7. Bare Piping in Equipment Rooms:
 - a. One piece, steel with polished, chrome-plated finish.
 - b. One piece, cast brass with **[polished, chrome-plated][rough-brass]** finish.
 - c. One piece, stamped steel **[or split plate, stamped steel with concealed hinge][or split plate, stamped steel with exposed-rivet hinge]** with polished, chrome-plated finish.

B. Escutcheons for Existing Piping to Remain:

1. Chrome-Plated Piping: Split plate, stamped steel with **[concealed][or][exposed-rivet]** hinge with polished, chrome-plated finish.
2. Insulated Piping: Split plate, stamped steel with **[concealed][or][exposed-rivet]** hinge with polished, chrome-plated finish.
3. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split plate, stamped steel with **[concealed][or][exposed-rivet]** hinge with polished, chrome-plated finish.
4. Bare Piping at Ceiling Penetrations in Finished Spaces: Split plate, stamped steel with **[concealed][or][exposed-rivet]** hinge with polished, chrome-plated finish.
5. Bare Piping in Unfinished Service Spaces: Split plate, stamped steel with **[concealed][or][exposed-rivet]** hinge with polished, chrome-plated finish.
6. Bare Piping in Equipment Rooms: Split plate, stamped steel with **[concealed][or][exposed-rivet]** hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping and Relocated Existing Piping: Split floor plate.
 - 2. Existing Piping to Remain: Split floor plate.

3.18 THERMOMETER APPLICATION

- A. Thermometers at inlet and outlet of each hydronic zone are to be the following:
 - 1. [Liquid-filled][Sealed], bimetallic-actuated type.
 - 2. [Direct][Remote]-mounted, [metal][plastic]-case, vapor-actuated type.
 - 3. [Compact][Industrial]-style, liquid-in-glass type.
 - 4. [Direct][Remote]-mounted, light-activated type.
 - 5. Test plug with [chlorosulfonated polyethylene synthetic][EPDM] self-sealing rubber inserts.
- B. Thermometers at inlet and outlet of each hydronic boiler are to be the following:
 - 1. [Liquid-filled][Sealed], bimetallic-actuated type.
 - 2. [Direct][Remote]-mounted, [metal][plastic]-case, vapor-actuated type.
 - 3. [Compact][Industrial]-style, liquid-in-glass type.
 - 4. [Direct][Remote]-mounted, light-activated type.
 - 5. Test plug with [chlorosulfonated polyethylene synthetic][EPDM] self-sealing rubber inserts.
- C. Thermometers at inlets and outlets of each chiller are to be the following:
 - 1. [Liquid-filled][Sealed], bimetallic-actuated type.
 - 2. [Direct][Remote]-mounted, [metal][plastic]-case, vapor-actuated type.
 - 3. [Compact][Industrial]-style, liquid-in-glass type.
 - 4. [Direct][Remote]-mounted, light-activated type.
 - 5. Test plug with [chlorosulfonated polyethylene synthetic][EPDM] self-sealing rubber inserts.
- D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems are to be the following:
 - 1. [Liquid-filled][Sealed], bimetallic-actuated type.
 - 2. [Direct][Remote]-mounted, [metal][plastic]-case, vapor-actuated type.
 - 3. [Compact][Industrial]-style, liquid-in-glass type.
 - 4. [Direct][Remote]-mounted, light-activated type.
 - 5. Test plug with [chlorosulfonated polyethylene synthetic][EPDM] self-sealing rubber inserts.
- E. Thermometers at inlets and outlets of each hydronic heat exchanger are to be the following:
 - 1. [Liquid-filled][Sealed], bimetallic-actuated type.
 - 2. [Direct][Remote]-mounted, [metal][plastic]-case, vapor-actuated type.
 - 3. [Compact][Industrial]-style, liquid-in-glass type.
 - 4. [Direct][Remote]-mounted, light-activated type.
 - 5. Test plug with [chlorosulfonated polyethylene synthetic][EPDM] self-sealing rubber inserts.
- F. Thermometers at inlet and outlet of each hydronic heat-recovery unit are to be the following:
 - 1. [Liquid-filled][Sealed], bimetallic-actuated type.
 - 2. [Direct][Remote]-mounted, [metal][plastic]-case, vapor-actuated type.
 - 3. [Compact][Industrial]-style, liquid-in-glass type.
 - 4. [Direct][Remote]-mounted, light-activated type.

5. Test plug with **[chlorosulfonated polyethylene synthetic][EPDM]** self-sealing rubber inserts.

G. Thermometers at inlet and outlet of each thermal-storage tank are to be the following:

1. **[Liquid-filled][Sealed]**, bimetallic-actuated type.
2. **[Direct][Remote]**-mounted, **[metal][plastic]**-case, vapor-actuated type.
3. **[Compact][Industrial]**-style, liquid-in-glass type.
4. **[Direct][Remote]**-mounted, light-activated type.
5. Test plug with **[chlorosulfonated polyethylene synthetic][EPDM]** self-sealing rubber inserts.

H. Thermometers at outside-, return-, supply-, and mixed-air ducts are to be the following:

1. **[Liquid-filled][Sealed]**, bimetallic-actuated type.
2. **[Direct][Remote]**-mounted, **[metal][plastic]**-case, vapor-actuated type.
3. **[Compact][Industrial]**-style, liquid-in-glass type.
4. **[Direct][Remote]**-mounted, light-activated type.

I. Thermometer stems are to be of length to match thermowell insertion length.

3.19 THERMOMETER SCALE-RANGE APPLICATION

A. Scale Range for Chilled-Water Piping:

1. **[Minus 40 to plus 160 deg F (Minus 40 to plus 100 deg C)][Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C].**
2. **[0 to 100 deg F (Minus 20 to plus 50 deg C)][0 to 100 deg F and minus 20 to plus 50 deg C].**
3. **[0 to 150 deg F (Minus 20 to plus 70 deg C)][0 to 150 deg F and minus 20 to plus 70 deg C].**
4. **[0 to 250 deg F (0 to 150 deg C)][0 to 250 deg F and 0 to 150 deg C].**

B. Scale Range for Condenser-Water Piping:

1. **[0 to 100 deg F (Minus 20 to plus 50 deg C)][0 to 100 deg F and minus 20 to plus 50 deg C].**
2. **[0 to 150 deg F (Minus 20 to plus 70 deg C)][0 to 150 deg F and minus 20 to plus 70 deg C].**
3. **[0 to 250 deg F (0 to 150 deg C)][0 to 250 deg F and 0 to 150 deg C].**
4. **[20 to 240 deg F (0 to 150 deg C)][20 to 240 deg F and 0 to 150 deg C].**
5. **[30 to 240 deg F (0 to plus 115 deg C)][30 to 240 deg F and 0 to plus 115 deg C].**

C. Scale Range for Heating, Hot-Water Piping:

1. **[0 to 250 deg F (0 to 150 deg C)][0 to 250 deg F and 0 to 150 deg C].**
2. **[20 to 240 deg F (0 to 150 deg C)][20 to 240 deg F and 0 to 150 deg C].**
3. **[30 to 240 deg F (0 to plus 115 deg C)][30 to 240 deg F and 0 to plus 115 deg C].**
4. **[50 to 400 deg F (0 to 200 deg C)][50 to 400 deg F and 0 to 200 deg C].**
5. **[50 to 550 deg F (10 to 300 deg C)][50 to 550 deg F and 10 to 300 deg C].**

D. Scale Range for Steam and Steam-Condensate Piping:

1. **[0 to 250 deg F (0 to 150 deg C)][0 to 250 deg F and 0 to 150 deg C].**
2. **[0 to 250 deg F (0 to 150 deg C)][0 to 250 deg F and 0 to 150 deg C].**
3. **[30 to 240 deg F (0 to plus 115 deg C)][30 to 240 deg F and 0 to plus 115 deg C].**
4. **[50 to 400 deg F (0 to 200 deg C)][50 to 400 deg F and 0 to 200 deg C].**

E. Scale Range for Air Ducts:

1. [Minus 40 to plus 110 deg F (Minus 40 to plus 45 deg C)][Minus 40 to plus 110 deg F and minus 40 to plus 45 deg C].
2. [Minus 40 to plus 160 deg F (Minus 40 to plus 100 deg C)][Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C].
3. [0 to 100 deg F (Minus 20 to plus 50 deg C)][0 to 100 deg F and minus 20 to plus 50 deg C].
4. [0 to 150 deg F (Minus 20 to plus 70 deg C)][0 to 150 deg F and minus 20 to plus 70 deg C].
5. [0 to 250 deg F (0 to 150 deg C)][0 to 250 deg F and 0 to 150 deg C].
6. [20 to 240 deg F (0 to 150 deg C)][20 to 240 deg F and 0 to 150 deg C].
7. [30 to 240 deg F (0 to plus 115 deg C)][30 to 240 deg F and 0 to plus 115 deg C].
8. [50 to 400 deg F (0 to 200 deg C)][50 to 400 deg F and 0 to 200 deg C].

3.20 PRESSURE-GAUGE APPLICATION

- A. Pressure gauges at discharge of each pressure-reducing valve are to be the following:
 1. [Liquid filled][Sealed][Open front, pressure relief][Solid front, pressure relief]<Insert type>, [direct][remote] mounted, metal case.
 2. [Sealed]<Insert type>, [direct][remote] mounted, plastic case.
 3. Test plug with [chlorosulfonated polyethylene synthetic][EPDM] self-sealing rubber inserts.
- B. Pressure gauges at inlet and outlet of each chiller chilled-water and condenser-water connection are to be the following:
 1. [Liquid filled][Sealed][Open front, pressure relief][Solid front, pressure relief]<Insert type>, [direct][remote] mounted, metal case.
 2. [Sealed]<Insert type>, [direct][remote] mounted, plastic case.
 3. Test plug with [chlorosulfonated polyethylene synthetic][EPDM] self-sealing rubber inserts.
- C. Pressure gauges at suction and discharge of each pump are to be the following:
 1. [Liquid-filled][Sealed][Open front, pressure relief][Solid front, pressure relief]<Insert type>, [direct][remote] mounted, metal case.
 2. [Sealed]<Insert type>, [direct][remote] mounted, plastic case.
 3. Test plug with [chlorosulfonated polyethylene synthetic][EPDM] self-sealing rubber inserts.

3.21 PRESSURE-GAUGE SCALE-RANGE APPLICATION

- A. Scale Range for Chilled-Water Piping:
 1. [30 in. Hg to 15 psi (minus 100 to 0 kPa)][30 in. Hg to 15 psi and minus 100 to 0 kPa].
 2. [0 to 30 psi (0 to 240 kPa)][0 to 30 psi and 0 to 240 kPa].
 3. [0 to 100 psi (0 to 600 kPa)][0 to 100 psi and 0 to 600 kPa].
 4. [0 to 160 psi (0 to 1100 kPa)][0 to 160 psi and 0 to 1100 kPa].
 5. [0 to 200 psi (0 to 1400 kPa)][0 to 200 psi and 0 to 1400 kPa].
 6. [0 to 300 psi (0 to 2500 kPa)][0 to 300 psi and 0 to 2500 kPa].
 7. [0 to 600 psi (0 to 4000 kPa)][0 to 600 psi and 0 to 4000 kPa].
- B. Scale Range for Condenser-Water Piping:
 1. [30 in. Hg to 15 psi (minus 100 to 0 kPa)][30 in. Hg to 15 psi and minus 100 to 0 kPa].
 2. [0 to 30 psi (0 to 240 kPa)][0 to 30 psi and 0 to 240 kPa].
 3. [0 to 100 psi (0 to 600 kPa)][0 to 100 psi and 0 to 600 kPa].
 4. [0 to 160 psi (0 to 1100 kPa)][0 to 160 psi and 0 to 1100 kPa].
 5. [0 to 200 psi (0 to 1400 kPa)][0 to 200 psi and 0 to 1400 kPa].

6. [0 to 300 psi (0 to 2500 kPa)][0 to 300 psi and 0 to 2500 kPa].
7. [0 to 600 psi (0 to 4000 kPa)][0 to 600 psi and 0 to 4000 kPa].

C. Scale Range for Heating, Hot-Water Piping:

1. [30 in. Hg to 15 psi (minus 100 to 0 kPa)][30 in. Hg to 15 psi and minus 100 to 0 kPa].
2. [0 to 30 psi (0 to 240 kPa)][0 to 30 psi and 0 to 240 kPa].
3. [0 to 100 psi (0 to 600 kPa)][0 to 100 psi and 0 to 600 kPa].
4. [0 to 160 psi (0 to 1100 kPa)][0 to 160 psi and 0 to 1100 kPa].
5. [0 to 200 psi (0 to 1400 kPa)][0 to 200 psi and 0 to 1400 kPa].
6. [0 to 300 psi (0 to 2500 kPa)][0 to 300 psi and 0 to 2500 kPa].
7. [0 to 600 psi (0 to 4000 kPa)][0 to 600 psi and 0 to 4000 kPa].

D. Scale Range for Steam Piping:

1. [30 in. Hg to 15 psi (minus 100 to 0 kPa)][30 in. Hg to 15 psi and minus 100 to 0 kPa].
2. [0 to 30 psi (0 to 240 kPa)][0 to 30 psi and 0 to 240 kPa].
3. [0 to 100 psi (0 to 600 kPa)][0 to 100 psi and 0 to 600 kPa].
4. [0 to 160 psi (0 to 1100 kPa)][0 to 160 psi and 0 to 1100 kPa].
5. [0 to 200 psi (0 to 1400 kPa)][0 to 200 psi and 0 to 1400 kPa].
6. [0 to 300 psi (0 to 2500 kPa)][0 to 300 psi and 0 to 2500 kPa].
7. [0 to 600 psi (0 to 4000 kPa)][0 to 600 psi and 0 to 4000 kPa].

3.22 FLOWMETER APPLICATION

- A. Flowmeters for Chilled-Water Piping: [Orifice][Pitot-tube][Turbine][Venturi][Vortex-shedding] type.
- B. Flowmeters for Condenser-Water Piping: [Orifice][Pitot-tube][Turbine][Venturi][Vortex-shedding] type.
- C. Flowmeters for Heating, Hot-Water Piping: [Orifice][Pitot-tube][Turbine][Venturi][Vortex-shedding] type.
- D. Flowmeters for Steam and Steam-Condensate Piping: [Orifice][Turbine][Venturi][Vortex-shedding] type.

3.23 THERMAL-ENERGY METER APPLICATION

- A. Thermal-Energy Meters for Chilled-Water Piping: [Turbine][Ultrasonic] type.
- B. Thermal-Energy Meters for Condenser-Water Piping: [Turbine][Ultrasonic] type.
- C. Thermal-Energy Meters for Heating, Hot-Water Piping: [Turbine][Ultrasonic] type.
- D. Thermal-Energy Meters for Steam and Steam-Condensate Piping: [Turbine][Ultrasonic] type.

END OF SECTION 23 05 00 00

SECTION 23 05 00 00A - COATINGS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes application of coating systems on internal HVAC components and external equipment surfaces, including the following systems:
 - 1. Bake-cured corrosion-resistant coating systems.
 - 2. Air-dried corrosion-resistant coating systems.

1.2 DEFINITIONS

- A. Salt Water Acetic Acid Test (SWAAT): A salt fog-spray test of corrosion resistance performed in accordance with ASTM G85, Annex 3.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include Safety Data Sheets, preparation requirements, and application instructions.
- B. Sustainable Design Submittals:
 - 1. Product Data: For paints and coatings, indicating VOC content.
 - 2. Laboratory Test Reports: For paints and coatings, indicating compliance with requirements for low-emitting materials.

1.4 INFORMATIONAL SUBMITTALS

- A. Source Quality-Control Reports:
 - 1. Certification of coating material testing.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Coatings: [1]<Insert number>[container][spray can] of each material and color applied [, including base coat and top coat products].

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in clean, dry, well-ventilated areas with ambient temperatures continuously maintained between **50 and 75 deg F (10 and 24 deg C)**.

1. Keep containers out of direct sunlight; avoid excessive heat and keep from freezing.
2. Maintain containers in clean condition, free of foreign materials and residue.
3. Remove rags and waste from storage areas daily.

1.7 CONDITIONS FOR COATING APPLICATION

- A. Comply with manufacturer's recommendations regarding required temperature and humidity ranges during coating application.

PART 2 - PRODUCTS

2.1 CORROSION-RESISTANT COATING SYSTEMS, GENERAL

- A. Material Compatibility:
 1. Provide materials for application within each coating system that are compatible with one another and with metal substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 2. For each coating material in coating system, submit compatibility certification from manufacturer of each coating product that products are compatible with substrate base material and with substrate-coating products applied as earlier coats.
 3. Products shall be of same manufacturer for each coat in a coating system.
- B. Colors: **[Manufacturer's standard]<Insert requirements>**.
- C. VOC Content, LEED 2009: For field applications that are inside the weatherproofing system, paints and coatings shall comply with VOC content limits of authorities having jurisdiction and the following VOC content limits:
 1. Flat Paints and Coatings: 50 g/L.
 2. Nonflat Paints and Coatings: 150 g/L.
 3. Dry-Fog Coatings: 400 g/L.
 4. Primers, Sealers, and Undercoaters: 200 g/L.
 5. Anticorrosive and Antirust Paints Applied to Ferrous Metals: 250 g/L.
 6. Zinc-Rich Industrial Maintenance Primers: 340 g/L.
 7. Pretreatment Wash Primers: 420 g/L.
 8. Shellacs, Clear: 730 g/L.
 9. Shellacs, Pigmented: 550 g/L.
- D. Low-Emitting Materials, LEED 2009: Interior paints and coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- E. VOC Content, LEED v4: For field applications that are inside the weatherproofing system, paints and coatings shall comply with VOC content limits of authorities having jurisdiction and the following VOC content limits:
 1. Flat Paints and Coatings: 50 g/L.
 2. Nonflat Paints and Coatings: 50 g/L.
 3. Dry-Fog Coatings: 150 g/L.
 4. Primers, Sealers, and Undercoaters: 100 g/L.

5. Rust-Preventive Coatings: 100 g/L.
 6. Zinc-Rich Industrial Maintenance Primers: 100 g/L.
 7. Pretreatment Wash Primers: 420 g/L.
 8. Shellacs, Clear: 730 g/L.
 9. Shellacs, Pigmented: 550 g/L.
- F. Low-Emitting Materials, LEED v4: For field applications that are inside the weatherproofing system, 90 percent of paints and coatings shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- G. Material Emissions and Pollutant Control: Not less than 85 percent of field-applied paints and coatings that are inside the weatherproofing system shall comply with either of the following:
1. Low-Emitting Materials: VOC emissions shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 2. VOC content shall not exceed limits of authorities having jurisdiction and the following:
 - a. Flat Coatings: 50 g/L.
 - b. Nonflat Coatings: 100 g/L.
 - c. Nonflat - High-Gloss Coatings: 150 g/L.
 - d. Dry-Fog Coatings: 150 g/L.
 - e. Industrial Maintenance Coatings: 250 g/L.
 - f. Pretreatment Wash Primers: 420 g/L.
 - g. Primers, Sealers, and Undercoaters: 100 g/L.
 - h. Recycled Coatings: 250 g/L.
 - i. Rust-Preventive Coatings: 250 g/L.
- H. Emissions Requirements: Field-applied paints and coatings that are inside the weatherproofing system shall comply with either of the following:
1. Low-Emitting Materials: VOC emissions shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 2. VOC content shall not exceed limits of authorities having jurisdiction and the following:
 - a. Flat Coatings: 50 g/L.
 - b. Nonflat Coatings: 100 g/L.
 - c. Primers, Sealers, and Undercoats: 100 g/L.
 - d. Shellacs, Clear: 730 g/L.
 - e. Shellacs, Pigmented: 550 g/L.
- I. VOC Content: For field applications inside the building, wall paints shall comply with VOC content limits of authorities having jurisdiction and the following VOC content limits:
1. Interior Flat Latex Wall Paint: 50 g/L.
 2. Interior Nonflat Latex Wall Paint: 150 g/L.
- J. VOC Emissions: For field applications inside the building, wall paints shall contain no more than half of the chronic REL of VOCs when tested according to the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit or 33 mcg/cu. m and that of acetaldehyde shall not exceed 9 mcg/cu. m.

2.2 BAKE-CURED CORROSION-RESISTANT COATING SYSTEMS

A. Base Coat Performance Requirements:

1. Corrosion Resistance: ASTM B117: [1500][2000][3500][6000]<Insert number> hours.
2. Cross-Hatch Adhesion: ASTM D3359: [5B]<Insert value>.
3. SWAAT: ASTM G85: [1000][Insert number] hours.
4. Cyclic Weathering: ISO 12944-9, [4200]<Insert number> hours.
5. Mandrel Flexibility: ASTM D522/D522M: [1/4 inch (6 mm)][1/2 inch (13 mm)]<Insert value> without cracking or delamination of film after full cure.
6. Adhesion - Elcometer: ASTM D4541: [1100 psi (7.6 MPa)]<Insert value>.
7. Impact: ASTM D2794.
 - a. Direct Hit: [70 lb.-in. (7.9 N-m)][80 lb.-in. (9.0 N-m)][90 lb.-in. (10.2 N-m)][100 lb.-in. (11.3 N-m)]<Insert value>.
 - b. Reverse Hit: [20 lb.-in. (2.2 N-m)][30 lb.-in. (3.4 N-m)][40 lb.-in. (4.5 N-m)][50 lb.-in. (5.6 N-m)]<Insert value>.
8. pH Range, 14-Day Liquid Spot Test: [2.4 to 12.6][or][3 to 12][Insert value].
9. Dry Heat Resistance: ASTM D2485: [320 deg F (160 deg C)][392 deg F (200 deg C)]<Insert value> maximum.
10. Dry Film Thickness: [0.5 to 1.2 mils (0.013 to 0.030 mm)][0.6 to 1.5 mils (0.015 to 0.038 mm)]<Insert thickness range>.
11. Heat-Transfer Reduction: [1 percent maximum]<Insert value>.
12. Hardness: ASTM D3363 Pencil Test: [2B-HB][5H-6H]<Insert value>.

B. Bake-Cured Coating for Equipment Serving Food-Preparation Areas: In accordance with NSF 51.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Heresite Protective Coatings]
 - b. [Modine Manufacturing Company]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Heresite Protective Coatings]
 - b. [Modine Manufacturing Company]
 - c. <Insert manufacturer's name>

C. Bake-Cured Top Coat:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Heresite Protective Coatings]
 - b. [Modine Manufacturing Company]
 - c. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Heresite Protective Coatings]**
 - b. **[Modine Manufacturing Company]**
 - c. **<Insert manufacturer's name>**
 3. Performance Requirements: Provide product with UV shielding properties, color stability, and maintenance of manufacturer's standard sheen, after exposure to outdoor conditions.
- D. Bake-Cured, Immersion-Applied Phenolic Epoxy System:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Heresite Protective Coatings]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Heresite Protective Coatings]**
 - b. **<Insert manufacturer's name>**
- E. Baked-Cured, Immersion-Applied Epoxy Coating System:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Modine Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Modine Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
- 2.3 AIR-DRIED CORROSION-RESISTANT COATING SYSTEMS
- A. Performance Requirements:
1. Corrosion Resistance: ASTM B117: **[1500][2000][3500]<Insert number>** hours.
 2. Cross-Hatch Adhesion: ASTM D3359: **[5B]<Insert value>**.
 3. Cyclic Weathering: ISO 12944-9, Offshore Standard: **[4200]<Insert number>** hours.
 4. Mandrel Flexibility: ASTM D522/D522M: **[1/2 inch (13 mm)][1/8 inch (3 mm)]<Insert value>** without cracking or delamination of film after full cure.
 5. Impact: ASTM D2794.

- a. Direct Hit: [100 in-lb (11.3 N-m)]<Insert value>.
 6. Dry Heat Resistance: ASTM D2485: [356 deg F (180 deg C)]<Insert value> maximum.
 7. Dry Film Thickness: [2 to 3 mils (0.050 to 0.075 mm)]<Insert thickness range>.
 8. Heat-Transfer Reduction: [1 percent]<Insert value> maximum.
 9. Hardness: ASTM D3363 Pencil Test: [2B-HB][2H][HBF]<Insert value>.
- B. Air-Dried, Spray-Applied Principle Coating System:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Blygold America]
 - b. [Heresite Protective Coatings]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Blygold America]
 - b. [Heresite Protective Coatings]
 - c. <Insert manufacturer's name>
- C. Air-Dried Phenolic System:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Heresite Protective Coatings]
 - b. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Heresite Protective Coatings]
 - b. <Insert manufacturer's name>
- D. Air-Dried, Spray-Applied Coating System:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Modine Manufacturing Company]
 - b. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. **[Modine Manufacturing Company]**
- b. **<Insert manufacturer's name>**

E. Air-Dried, Spray-Applied, Polyurethane Mixed with Aluminum Flakes System:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Blygold America]**
 - b. **[Energy Guard USA]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Blygold America]**
 - b. **[Energy Guard USA]**
 - c. **<Insert manufacturer's name>**

F. Base Coat Performance Requirements:

- 1. Corrosion Resistance: ASTM B117: **[1500][2000][3000][4000][5000][6000][10,000]<Insert number>** hours.
- 2. SWAAT: ASTM G85: **[1000][Insert number]** hours.
- 3. Cyclic Weathering: ISO 12944-9: **[4200]<Insert number>** hours.
- 4. Cross-Hatch Adhesion: ASTM D3359: **[5B]<Insert value>**.
- 5. Mandrel Flexibility: ASTM D522/D522M: **[1/8 inch (3 mm)][1/4 inch (6 mm)][1/2 inch (13 mm)]<Insert value>** without cracking or delamination of film after full cure.
- 6. Adhesion - Elcometer: ASTM D4541: **[1,100 psi (7.6 MPa)]<Insert value>**
- 7. Impact: ASTM D2794.
 - a. Direct Hit: **[100 lb.-in. (11.3 N-m)][160 lb.-in. (18.0 N-m)]<Insert value>**.
- 8. Dry Heat Resistance: ASTM D2485: **[250 deg F (121 deg C)]<Insert value>** maximum.
- 9. Dry Film Thickness: **[0.5 to 1.2 mils (0.013 to 0.030 mm)][0.6 to 1.5 mils (0.015 to 0.038 mm)]<Insert thickness range>**.
- 10. Heat-Transfer Reduction: **[1 percent]<Insert value>** maximum.
- 11. Hardness: ASTM D3363 Pencil Test: **[2B-HB][HB-F]<Insert value>**.

G. Air-Dried Coating for Equipment Serving Food-Preparation Areas: In accordance with 21 CFR 175.300.

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Heresite Protective Coatings]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. **[Heresite Protective Coatings]**
- b. **<Insert manufacturer's name>**

H. Spray-Can Application System:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Heresite Protective Coatings]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Heresite Protective Coatings]**
 - b. **<Insert manufacturer's name>**
- 3. Spray-Can Application System Air-Dried Top Coat Performance Requirements: Provide product with UV shielding properties, color stability, and maintenance of manufacturer's standard sheen, after exposure to outdoor conditions.
 - a. Type: Air dry, phenolic.

2.4 SOURCE QUALITY CONTROL

- A. Certification of Coating Material Testing: Submit manufacturer's test report of corrosion-resistance performance testing, as performed by a nationally recognized testing laboratory.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with coating manufacturer's requirements and other conditions affecting performance of the Work.
- B. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.
- C. Proceed with coating application only after unsatisfactory conditions have been corrected.
 - 1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions applicable to substrates and coating systems indicated.

1. Thinning: Thin coating material with manufacturer's recommended thinning products when recommended or permitted by coating system manufacturer.
- B. Comply with coating system manufacturer's recommendations to clean substrates of substances that could impair bond of coatings, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

3.3 APPLICATION

- A. Verify with coating manufacturer whether coatings required must be applied and cured in factory-certified application shop.
- B. Apply coating systems with equipment designed to deposit coating of specified uniform thickness over HVAC components, in complex, three-dimensional geometries.
 1. Apply coatings with manufacturer-recommended tools and techniques suited for specified coating system and each coated HVAC component.
 2. Do not apply coatings over labels or equipment name, identification, performance rating, or nomenclature plates.
- C. Perform inspection and coating system manufacturer's recommended tests to verify coating integrity and thickness. Where coating was damaged by testing, repair damage in accordance with coating system manufacturer's written recommendations.

END OF SECTION 23 05 00 00A



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 05 00 00	05 12 00 00a	Architecturally Exposed Structural Steel Framing
23 05 13 00	23 05 00 00a	Coatings for HVAC
23 05 16 00	23 05 00 00a	Coatings for HVAC
23 05 17 00	21 05 00 00	Common Work Results for Fire Suppression
23 05 17 00	22 05 00 00	Common Work Results for Plumbing
23 05 17 00	23 05 00 00	Common Work Results for HVAC
23 05 17 00	23 05 00 00a	Coatings for HVAC
23 05 19 00	21 05 00 00	Common Work Results for Fire Suppression
23 05 19 00	22 05 00 00	Common Work Results for Plumbing
23 05 19 00	23 05 00 00	Common Work Results for HVAC
23 05 19 00	23 05 00 00a	Coatings for HVAC



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 05 23 00 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Angle valves.
2. Globe valves.
3. Ball valves.
4. Butterfly valves.
5. Check valves.
6. Gate valves.
7. Plug valves.
8. Chainwheels.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene-propylene-diene monomer.
- C. FKM: Fluoroelastomer.
- D. NBR: Nitrile butadiene rubber (also known as "Buna-N").
- E. NRS: Nonrising stem.
- F. OS&Y: Outside screw and yoke.
- G. PTFE: Polytetrafluoroethylene.
- H. RPTFE: Reinforced polytetrafluoroethylene.
- I. RS: Rising stem.
- J. SWP: Steam working pressure.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 1. Include material descriptions and dimensions of individual components.
 2. Include operating characteristics and furnished accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
 2. Protect threads, flange faces, grooved ends, press ends, solder ends, and weld ends.
 3. Set ball valves open to minimize exposure of functional surfaces.
 4. Set butterfly valves closed or slightly open.
 5. Block check valves in either closed or open position.
 6. Set gate valves closed to prevent rattling.
 7. Set plug valves to open to minimize exposure of functional surfaces.
- B. Use the following precautions during storage:
1. Maintain valve end protection.
 2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves.
 2. ASME B16.1 for flanges on iron valves.
 3. ASME B16.5 for flanges on steel valves.
 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 5. ASME B16.18 for cast-copper solder-joint connections.
 6. ASME B16.22 for wrought copper and copper-alloy solder-joint connections.
 7. ASME B16.34 for flanged- and threaded-end connections.
 8. ASME B16.51 for press joint connections.
 9. ASME B31.1 for power piping valves.
 10. ASME B31.9 for building services piping valves.
- B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valve Bypass and Drain Connections: MSS SP-45.

- G. Wrench: Furnish Owner with one wrench for every **[five][10]<Insert number>** plug valves, for each size square plug-valve head.
- H. Valve Actuator Type:
 - 1. Gear Actuator: For quarter-turn ball valves **[NPS 4 (DN 100)]<Insert pipe size>** and larger.
 - 2. Hand Lever: For quarter-turn ball valves smaller than **[NPS 4 (DN 100)]<Insert pipe size>**.
- I. Valves in Insulated Piping:
 - 1. Provide **2-inch (50-mm)** extended neck stems.
 - 2. Provide extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
 - 3. Provide memory stops that are fully adjustable after insulation is applied.

2.3 ANGLE VALVES

- A. Angle Valves, Threaded Ends - Bronze, Class 125:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Valve, Inc]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Hammond Valve]**
 - d. **[Milwaukee Valve Company]**
 - e. **[NIBCO INC.]**
 - f. **[WATTS; A Watts Water Technologies Company]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Hammond Valve]**
 - d. **[Milwaukee Valve Company]**
 - e. **[NIBCO INC.]**
 - f. **[WATTS; A Watts Water Technologies Company]**
 - g. **<Insert manufacturer's name>**
 - 3. Standard: MSS SP-80, Type 1.
 - 4. CWP Rating: **200 psig (1380 kPa)**.
 - 5. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
 - 6. Ends: Threaded.
 - 7. Stem: Bronze.
 - 8. Disc: PTFE.
 - 9. Packing: Asbestos free.
 - 10. Handwheel: Malleable iron[, **bronze, or aluminum**].
- B. Angle Valves, Threaded Ends - Bronze, Class 150:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Crane Fluid Systems; Crane Co.]**
 - b. **[KITZ Corporation]**
 - c. **[Milwaukee Valve Company]**
 - d. **[Stockham; a Crane Co. brand]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crane Fluid Systems; Crane Co.]**
 - b. **[KITZ Corporation]**
 - c. **[Milwaukee Valve Company]**
 - d. **[Stockham; a Crane Co. brand]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **<Insert manufacturer's name>**
3. Standard: MSS SP-80, Type 1.
4. CWP Rating: **300 psig (2070 kPa)**.
5. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
6. Ends: Threaded.
7. Stem: Bronze.
8. Disc: PTFE or stainless steel. See Part 3 angle valve schedule articles.
9. Packing: Asbestos free.
10. Handwheel: Malleable iron[, **bronze, or aluminum**].

2.4 GLOBE VALVES

A. Globe Valves, Threaded or Soldered Ends - Bronze, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[FNW; Ferguson Enterprises, Inc.]**
 - d. **[Hammond Valve]**
 - e. **[KITZ Corporation]**
 - f. **[Milwaukee Valve Company]**
 - g. **[NIBCO INC.]**
 - h. **[Powell Valves]**
 - i. **[Red-White Valve Corp.]**
 - j. **[Stockham; a Crane Co. brand]**
 - k. **[WATTS; A Watts Water Technologies Company]**
 - l. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[FNW; Ferguson Enterprises, Inc.]**
 - d. **[Hammond Valve]**
 - e. **[KITZ Corporation]**
 - f. **[Milwaukee Valve Company]**
 - g. **[NIBCO INC.]**
 - h. **[Powell Valves]**
 - i. **[Red-White Valve Corp.]**
 - j. **[Stockham; a Crane Co. brand]**
 - k. **[WATTS; A Watts Water Technologies Company]**
 - l. **<Insert manufacturer's name>**
 3. Standard: MSS SP-80, Type 1.
 4. CWP Rating: **200 psig (1380 kPa)**.
 5. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
 6. Ends: Threaded or soldered. See Part 3 globe valve schedule articles.
 7. Stem: Bronze.
 8. Disc: PTFE.
 9. Packing: Asbestos free.
 10. Handwheel: Malleable iron[, **bronze, or aluminum**].
- B. Globe Valves, Threaded Ends - Bronze, Class 150:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Hammond Valve]**
 - d. **[KITZ Corporation]**
 - e. **[Milwaukee Valve Company]**
 - f. **[NIBCO INC.]**
 - g. **[Powell Valves]**
 - h. **[Red-White Valve Corp.]**
 - i. **[Siemens Industry, Inc., Building Technologies Division]**
 - j. **[Valve Solutions, Inc.]**
 - k. **[WATTS; A Watts Water Technologies Company]**
 - l. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Hammond Valve]**
 - d. **[KITZ Corporation]**
 - e. **[Milwaukee Valve Company]**
 - f. **[NIBCO INC.]**

- g. [Powell Valves]
- h. [Red-White Valve Corp.]
- i. [Siemens Industry, Inc., Building Technologies Division]
- j. [Valve Solutions, Inc.]
- k. [WATTS; A Watts Water Technologies Company]
- l. <Insert manufacturer's name>

- 3. Standard: MSS SP-80, Type 2.
- 4. CWP Rating: **300 psig (2070 kPa)**.
- 5. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
- 6. Ends: Threaded.
- 7. Stem: Bronze.
- 8. Disc: PTFE or stainless steel. See Part 3 globe valve schedule articles.
- 9. Packing: Asbestos free.
- 10. Handwheel: Malleable iron[, **bronze, or aluminum**].

C. Globe Valves, Flanged Ends - Iron, Class 125:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Crane Fluid Systems; Crane Co.]
 - c. [FNW; Ferguson Enterprises, Inc.]
 - d. [Hammond Valve]
 - e. [Jenkins Valves; a Crane Co. brand]
 - f. [KITZ Corporation]
 - g. [Milwaukee Valve Company]
 - h. [NIBCO INC.]
 - i. [Powell Valves]
 - j. [Red-White Valve Corp.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. [Stockham; a Crane Co. brand]
 - m. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Crane Fluid Systems; Crane Co.]
 - c. [FNW; Ferguson Enterprises, Inc.]
 - d. [Hammond Valve]
 - e. [Jenkins Valves; a Crane Co. brand]
 - f. [KITZ Corporation]
 - g. [Milwaukee Valve Company]
 - h. [NIBCO INC.]
 - i. [Powell Valves]
 - j. [Red-White Valve Corp.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. [Stockham; a Crane Co. brand]
 - m. <Insert manufacturer's name>

3. Standard: MSS SP-85, Type I.
4. CWP Rating: **200 psig (1380 kPa)**.
5. Body Material: ASTM A126, gray iron with bolted bonnet.
6. Ends: Flanged.
7. Trim: Bronze.
8. Packing and Gasket: Asbestos free.
9. Operator: Handwheel or chainwheel.

D. Globe Valves, Flanged Ends - Iron, Class 250:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Hammond Valve]**
 - d. **[Jenkins Valves; a Crane Co. brand]**
 - e. **[Milwaukee Valve Company]**
 - f. **[NIBCO INC.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **[Stockham; a Crane Co. brand]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Hammond Valve]**
 - d. **[Jenkins Valves; a Crane Co. brand]**
 - e. **[Milwaukee Valve Company]**
 - f. **[NIBCO INC.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **[Stockham; a Crane Co. brand]**
 - i. **<Insert manufacturer's name>**
3. Standard: MSS SP-85, Type I.
4. CWP Rating: **500 psig (3450 kPa)**.
5. Body Material: ASTM A126, gray iron with bolted bonnet.
6. Ends: Flanged.
7. Trim: Bronze.
8. Packing and Gasket: Asbestos free.
9. Operator: Handwheel or chainwheel.

2.5 BALL VALVES

A. Ball Valves, Threaded Ends - Brass, One Piece:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [KITZ Corporation]
 - b. [WATTS; A Watts Water Technologies Company]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [KITZ Corporation]
 - b. [WATTS; A Watts Water Technologies Company]
 - c. <Insert manufacturer's name>
3. Standard: MSS SP-110.
4. CWP Rating: **400 psig (2760 kPa)**.
5. Body Design: One piece.
6. Body Material: Forged brass.
7. Ends: Threaded.
8. Seats: PTFE.
9. Stem: Brass.
10. Ball: Chrome-plated brass.
11. Port: Reduced.

B. Ball Valves, Threaded or Soldered Ends - Brass, Two Piece with Full Port and Brass Trim:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [A.Y. McDonald Mfg. Co.]
 - b. [American Valve, Inc]
 - c. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - d. [Bray International, Inc.]
 - e. [Center Line; a Crane Co. brand]
 - f. [DynaQuip Controls]
 - g. [FNW; Ferguson Enterprises, Inc.]
 - h. [Hammond Valve]
 - i. [Jenkins Valves; a Crane Co. brand]
 - j. [Jomar Valve]
 - k. [KITZ Corporation]
 - l. [Lance Valves]
 - m. [Legend Valve & Fitting, Inc]
 - n. [Marwin Valve; Richards Industries]
 - o. [Milwaukee Valve Company]
 - p. [Red-White Valve Corp.]
 - q. [Siemens Industry, Inc., Building Technologies Division]
 - r. [Stockham; a Crane Co. brand]
 - s. [Viega LLC]
 - t. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [A.Y. McDonald Mfg. Co.]

- b. [American Valve, Inc]
 - c. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - d. [Bray International, Inc.]
 - e. [Center Line; a Crane Co. brand]
 - f. [DynaQuip Controls]
 - g. [FNW; Ferguson Enterprises, Inc.]
 - h. [Hammond Valve]
 - i. [Jenkins Valves; a Crane Co. brand]
 - j. [Jomar Valve]
 - k. [KITZ Corporation]
 - l. [Lance Valves]
 - m. [Legend Valve & Fitting, Inc]
 - n. [Marwin Valve; Richards Industries]
 - o. [Milwaukee Valve Company]
 - p. [Red-White Valve Corp.]
 - q. [Siemens Industry, Inc., Building Technologies Division]
 - r. [Stockham; a Crane Co. brand]
 - s. [Viega LLC]
 - t. <Insert manufacturer's name>
3. Standard: MSS SP-110.
 4. SWP Rating: **150 psig (1035 kPa)**.
 5. CWP Rating: **600 psig (4140 kPa)**.
 6. Body Design: Two piece.
 7. Body Material: Forged brass.
 8. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
 9. Seats: PTFE.
 10. Stem: Brass.
 11. Ball: Chrome-plated brass.
 12. Port: Full.
- C. Ball Valves, Press Ends - Brass, Two Piece with Full Port and Brass Trim:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [American Valve, Inc]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Crane Fluid Systems; Crane Co.]
 - d. [FNW; Ferguson Enterprises, Inc.]
 - e. [Hammond Valve]
 - f. [Jenkins Valves; a Crane Co. brand]
 - g. [Jomar Valve]
 - h. [KITZ Corporation]
 - i. [Lance Valves]
 - j. [Legend Valve & Fitting, Inc]
 - k. [Milwaukee Valve Company]
 - l. [Red-White Valve Corp.]
 - m. [Stockham; a Crane Co. brand]
 - n. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [American Valve, Inc]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [Crane Fluid Systems; Crane Co.]
- d. [FNW; Ferguson Enterprises, Inc.]
- e. [Hammond Valve]
- f. [Jenkins Valves; a Crane Co. brand]
- g. [Jomar Valve]
- h. [KITZ Corporation]
- i. [Lance Valves]
- j. [Legend Valve & Fitting, Inc]
- k. [Milwaukee Valve Company]
- l. [Red-White Valve Corp.]
- m. [Stockham; a Crane Co. brand]
- n. <Insert manufacturer's name>

- 3. Standards: MSS SP-110 and IAPMO/ANSI Z1157.
- 4. CWP Rating: **600 psig (4140 kPa)**.
- 5. Body Design: Two piece.
- 6. Body Material: Forged brass.
- 7. Ends: Press.
- 8. Seats: PTFE or RPTFE.
- 9. Stem: Brass.
- 10. Ball: Chrome-plated brass.
- 11. Port: Full.
- 12. O-Ring Seal: NBR or EPDM.

D. Ball Valves, Threaded or Soldered Ends - Brass, Two Piece with Full Port and Stainless Steel Trim:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. [A.Y. McDonald Mfg. Co.]
- b. [American Valve, Inc]
- c. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- d. [Crane Fluid Systems; Crane Co.]
- e. [DynaQuip Controls]
- f. [Flow-Tek; a subsidiary of Bray International]
- g. [FNW; Ferguson Enterprises, Inc.]
- h. [Hammond Valve]
- i. [Jamesbury; a brand of Valmet]
- j. [Jenkins Valves; a Crane Co. brand]
- k. [Jomar Valve]
- l. [KITZ Corporation]
- m. [Lance Valves]
- n. [Legend Valve & Fitting, Inc]
- o. [Marwin Valve; Richards Industries]
- p. [Milwaukee Valve Company]
- q. [Red-White Valve Corp.]
- r. [RuB Inc]
- s. [Siemens Industry, Inc., Building Technologies Division]
- t. [Stockham; a Crane Co. brand]
- u. [Viega LLC]
- v. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[American Valve, Inc]**
 - c. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - d. **[Crane Fluid Systems; Crane Co.]**
 - e. **[DynaQuip Controls]**
 - f. **[Flow-Tek; a subsidiary of Bray International]**
 - g. **[FNW; Ferguson Enterprises, Inc.]**
 - h. **[Hammond Valve]**
 - i. **[Jamesbury; a brand of Valmet]**
 - j. **[Jenkins Valves; a Crane Co. brand]**
 - k. **[Jomar Valve]**
 - l. **[KITZ Corporation]**
 - m. **[Lance Valves]**
 - n. **[Legend Valve & Fitting, Inc]**
 - o. **[Marwin Valve; Richards Industries]**
 - p. **[Milwaukee Valve Company]**
 - q. **[Red-White Valve Corp.]**
 - r. **[RuB Inc]**
 - s. **[Siemens Industry, Inc., Building Technologies Division]**
 - t. **[Stockham; a Crane Co. brand]**
 - u. **[Viega LLC]**
 - v. **<Insert manufacturer's name>**
3. Standard: MSS SP-110.
4. SWP Rating: **150 psig (1035 kPa)**.
5. CWP Rating: **600 psig (4140 kPa)**.
6. Body Design: Two piece.
7. Body Material: Forged brass.
8. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
9. Seats: PTFE.
10. Stem: Stainless steel.
11. Ball: Stainless steel, vented.
12. Port: Full.

E. Ball Valves, Press Ends - Brass, Two Piece with Full Port and Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
- a. **[American Valve, Inc]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Crane Fluid Systems; Crane Co.]**
 - d. **[FNW; Ferguson Enterprises, Inc.]**
 - e. **[Hammond Valve]**
 - f. **[Jomar Valve]**
 - g. **[KITZ Corporation]**
 - h. **[Lance Valves]**
 - i. **[Legend Valve & Fitting, Inc]**
 - j. **[Milwaukee Valve Company]**
 - k. **[NIBCO INC.]**

- l. [Red-White Valve Corp.]
- m. [RuB Inc]
- n. [Stockham; a Crane Co. brand]
- o. [Viega LLC]
- p. [WATTS; A Watts Water Technologies Company]
- q. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [American Valve, Inc]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [Crane Fluid Systems; Crane Co.]
- d. [FNW; Ferguson Enterprises, Inc.]
- e. [Hammond Valve]
- f. [Jomar Valve]
- g. [KITZ Corporation]
- h. [Lance Valves]
- i. [Legend Valve & Fitting, Inc]
- j. [Milwaukee Valve Company]
- k. [NIBCO INC.]
- l. [Red-White Valve Corp.]
- m. [RuB Inc]
- n. [Stockham; a Crane Co. brand]
- o. [Viega LLC]
- p. [WATTS; A Watts Water Technologies Company]
- q. <Insert manufacturer's name>

- 3. Standards: MSS SP-110 and IAPMO/ANSI Z1157.
- 4. CWP Rating: Minimum **200 psig (1380 kPa)**.
- 5. Body Design: Two piece.
- 6. Body Material: Forged brass.
- 7. Ends: Press.
- 8. Press-End Connections Rating: Minimum **200 psig (1380 kPa)**.
- 9. Seats: PTFE or RPTFE.
- 10. Stem: Stainless steel.
- 11. Ball: Stainless steel, vented.
- 12. Port: Full.
- 13. O-Ring Seal: NBR or EPDM.

- F. Ball Valves, Threaded or Soldered Ends - Brass, Two Piece with Regular Port and Brass Trim:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [A.Y. McDonald Mfg. Co.]
 - b. [American Valve, Inc]
 - c. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - d. [Center Line; a Crane Co. brand]
 - e. [FNW; Ferguson Enterprises, Inc.]
 - f. [Hammond Valve]
 - g. [Jamesbury; a brand of Valmet]

- h. [Jomar Valve]
 - i. [KITZ Corporation]
 - j. [Lance Valves]
 - k. [Legend Valve & Fitting, Inc]
 - l. [Marwin Valve; Richards Industries]
 - m. [Milwaukee Valve Company]
 - n. [NIBCO INC.]
 - o. [Red-White Valve Corp.]
 - p. [Siemens Industry, Inc., Building Technologies Division]
 - q. [Stockham; a Crane Co. brand]
 - r. [Viega LLC]
 - s. [WATTS; A Watts Water Technologies Company]
 - t. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [A.Y. McDonald Mfg. Co.]
 - b. [American Valve, Inc]
 - c. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - d. [Center Line; a Crane Co. brand]
 - e. [FNW; Ferguson Enterprises, Inc.]
 - f. [Hammond Valve]
 - g. [Jamesbury; a brand of Valmet]
 - h. [Jomar Valve]
 - i. [KITZ Corporation]
 - j. [Lance Valves]
 - k. [Legend Valve & Fitting, Inc]
 - l. [Marwin Valve; Richards Industries]
 - m. [Milwaukee Valve Company]
 - n. [NIBCO INC.]
 - o. [Red-White Valve Corp.]
 - p. [Siemens Industry, Inc., Building Technologies Division]
 - q. [Stockham; a Crane Co. brand]
 - r. [Viega LLC]
 - s. [WATTS; A Watts Water Technologies Company]
 - t. <Insert manufacturer's name>
 3. Standard: MSS SP-110.
 4. SWP Rating: **150 psig (1035 kPa)**.
 5. CWP Rating: **600 psig (4140 kPa)**.
 6. Body Design: Two piece.
 7. Body Material: Forged brass.
 8. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
 9. Seats: PTFE.
 10. Stem: Brass.
 11. Ball: Chrome-plated brass.
 12. Port: Regular.
- G. Ball Valves, Threaded or Soldered Ends - Brass, Two Piece with Regular Port and Stainless Steel Trim:
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [A.Y. McDonald Mfg. Co.]
 - b. [American Valve, Inc]
 - c. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - d. [Center Line; a Crane Co. brand]
 - e. [FNW; Ferguson Enterprises, Inc.]
 - f. [Hammond Valve]
 - g. [Jomar Valve]
 - h. [KITZ Corporation]
 - i. [Lance Valves]
 - j. [Legend Valve & Fitting, Inc]
 - k. [Marwin Valve; Richards Industries]
 - l. [Milwaukee Valve Company]
 - m. [Red-White Valve Corp.]
 - n. [Siemens Industry, Inc., Building Technologies Division]
 - o. [Stockham; a Crane Co. brand]
 - p. [Viega LLC]
 - q. [WATTS; A Watts Water Technologies Company]
 - r. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [A.Y. McDonald Mfg. Co.]
 - b. [American Valve, Inc]
 - c. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - d. [Center Line; a Crane Co. brand]
 - e. [FNW; Ferguson Enterprises, Inc.]
 - f. [Hammond Valve]
 - g. [Jomar Valve]
 - h. [KITZ Corporation]
 - i. [Lance Valves]
 - j. [Legend Valve & Fitting, Inc]
 - k. [Marwin Valve; Richards Industries]
 - l. [Milwaukee Valve Company]
 - m. [Red-White Valve Corp.]
 - n. [Siemens Industry, Inc., Building Technologies Division]
 - o. [Stockham; a Crane Co. brand]
 - p. [Viega LLC]
 - q. [WATTS; A Watts Water Technologies Company]
 - r. <Insert manufacturer's name>
3. Standard: MSS SP-110.
4. SWP Rating: **150 psig (1035 kPa)**.
5. CWP Rating: **600 psig (4140 kPa)**.
6. Body Design: Two piece.
7. Body Material: Brass or bronze.
8. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
9. Seats: PTFE.
10. Stem: Stainless steel.
11. Ball: Stainless steel, vented.
12. Port: Regular.

H. Ball Valves, Threaded or Soldered Ends - Brass, Three Piece with Full Port and Brass Trim:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bray International, Inc.]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bray International, Inc.]**
 - b. **<Insert manufacturer's name>**
 3. Standard: MSS SP-110.
 4. SWP Rating: **150 psig (1035 kPa)**.
 5. CWP Rating: **600 psig (4140 kPa)**.
 6. Body Design: Three piece.
 7. Body Material: Forged brass.
 8. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
 9. Seats: PTFE.
 10. Stem: Brass.
 11. Ball: Chrome-plated brass.
 12. Port: Full.
- I. Ball Valves, Threaded or Soldered Ends - Brass, Three Piece with Full Port and Stainless Steel Trim:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bray International, Inc.]**
 - b. **[DynaQuip Controls]**
 - c. **[Marwin Valve; Richards Industries]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bray International, Inc.]**
 - b. **[DynaQuip Controls]**
 - c. **[Marwin Valve; Richards Industries]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **<Insert manufacturer's name>**
 3. Standard: MSS SP-110.
 4. SWP Rating: **150 psig (1035 kPa)**.
 5. CWP Rating: **600 psig (4140 kPa)**.
 6. Body Design: Three piece.
 7. Body Material: Forged brass.
 8. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
 9. Seats: PTFE.



10. Stem: Stainless steel.
11. Ball: Stainless steel, vented.
12. Port: Full.

J. Ball Valves, Threaded Ends - Bronze, One Piece with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[NIBCO INC.]**
 - b. **[WATTS; A Watts Water Technologies Company]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[NIBCO INC.]**
 - b. **[WATTS; A Watts Water Technologies Company]**
 - c. **<Insert manufacturer's name>**
3. Standard: MSS SP-110.
4. CWP Rating: **400 psig (2760 kPa)**.
5. Body Design: One piece.
6. Body Material: Bronze.
7. Ends: Threaded.
8. Seats: PTFE.
9. Stem: Bronze.
10. Ball: Chrome-plated brass.
11. Port: Reduced.

K. Ball Valves, Threaded Ends - Bronze, One Piece with Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[NIBCO INC.]**
 - b. **[WATTS; A Watts Water Technologies Company]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[NIBCO INC.]**
 - b. **[WATTS; A Watts Water Technologies Company]**
 - c. **<Insert manufacturer's name>**
3. Standard: MSS SP-110.
4. CWP Rating: **600 psig (4140 kPa)**.
5. Body Design: One piece.

6. Body Material: Bronze.
 7. Ends: Threaded.
 8. Seats: PTFE.
 9. Stem: Stainless steel.
 10. Ball: Stainless steel, vented.
 11. Port: Reduced.
- L. Ball Valves, Threaded or Soldered Ends - Bronze, Two Piece with Full Port and Bronze or Brass Trim:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[DynaQuip Controls]**
 - d. **[FNW; Ferguson Enterprises, Inc.]**
 - e. **[Hammond Valve]**
 - f. **[Jenkins Valves; a Crane Co. brand]**
 - g. **[Milwaukee Valve Company]**
 - h. **[NIBCO INC.]**
 - i. **[Red-White Valve Corp.]**
 - j. **[Stockham; a Crane Co. brand]**
 - k. **[Zurn Industries, LLC]**
 - l. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[DynaQuip Controls]**
 - d. **[FNW; Ferguson Enterprises, Inc.]**
 - e. **[Hammond Valve]**
 - f. **[Jenkins Valves; a Crane Co. brand]**
 - g. **[Milwaukee Valve Company]**
 - h. **[NIBCO INC.]**
 - i. **[Red-White Valve Corp.]**
 - j. **[Stockham; a Crane Co. brand]**
 - k. **[Zurn Industries, LLC]**
 - l. **<Insert manufacturer's name>**
 3. Standard: MSS SP-110.
 4. SWP Rating: **150 psig (1035 kPa)**.
 5. CWP Rating: **600 psig (4140 kPa)**.
 6. Body Design: Two piece.
 7. Body Material: Bronze.
 8. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
 9. Seats: PTFE.
 10. Stem: Bronze.
 11. Ball: Chrome-plated brass.
 12. Port: Full.
- M. Ball Valves, Press Ends - Bronze, Two Piece with Full Port and Bronze or Brass Trim:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Center Line; a Crane Co. brand]**
 - c. **[Hammond Valve]**
 - d. **[Milwaukee Valve Company]**
 - e. **[NIBCO INC.]**
 - f. **[Red-White Valve Corp.]**
 - g. **[Stockham; a Crane Co. brand]**
 - h. **[Viega LLC]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Center Line; a Crane Co. brand]**
 - c. **[Hammond Valve]**
 - d. **[Milwaukee Valve Company]**
 - e. **[NIBCO INC.]**
 - f. **[Red-White Valve Corp.]**
 - g. **[Stockham; a Crane Co. brand]**
 - h. **[Viega LLC]**
 - i. **<Insert manufacturer's name>**
3. Standards: MSS SP-110 and IAPMO/ANSI Z1157.
4. CWP Rating: Minimum **200 psig (1380 kPa)**.
5. Body Design: Two piece.
6. Body Material: Bronze.
7. Ends: Press.
8. Press-End Connections Rating: Minimum **200 psig (1380 kPa)**.
9. Seats: PTFE or RPTFE.
10. Stem: Bronze or brass.
11. Ball: Chrome-plated brass.
12. Port: Full.
13. O-Ring Seal: EPDM or NBR.

N. Ball Valves, Threaded or Soldered Ends - Bronze, Two Piece with Full Port and Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[DynaQuip Controls]**
 - d. **[Hammond Valve]**
 - e. **[Jenkins Valves; a Crane Co. brand]**
 - f. **[Milwaukee Valve Company]**
 - g. **[NIBCO INC.]**

- h. [Red-White Valve Corp.]
 - i. [Stockham; a Crane Co. brand]
 - j. [Viega LLC]
 - k. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Crane Fluid Systems; Crane Co.]
 - c. [DynaQuip Controls]
 - d. [Hammond Valve]
 - e. [Jenkins Valves; a Crane Co. brand]
 - f. [Milwaukee Valve Company]
 - g. [NIBCO INC.]
 - h. [Red-White Valve Corp.]
 - i. [Stockham; a Crane Co. brand]
 - j. [Viega LLC]
 - k. <Insert manufacturer's name>
- 3. Standard: MSS SP-110.
- 4. SWP Rating: **150 psig (1035 kPa)**.
- 5. CWP Rating: **600 psig (4140 kPa)**.
- 6. Body Design: Two piece.
- 7. Body Material: Bronze.
- 8. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
- 9. Seats: PTFE.
- 10. Stem: Stainless steel.
- 11. Ball: Stainless steel, vented.
- 12. Port: Full.
- O. Ball Valves, Threaded Ends - Bronze, Two Piece with Regular Port and Bronze or Brass Trim:
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Valve, Inc]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Center Line; a Crane Co. brand]
 - d. [DynaQuip Controls]
 - e. [Hammond Valve]
 - f. [Jenkins Valves; a Crane Co. brand]
 - g. [Jomar Valve]
 - h. [Lance Valves]
 - i. [Milwaukee Valve Company]
 - j. [NIBCO INC.]
 - k. [Red-White Valve Corp.]
 - l. [Stockham; a Crane Co. brand]
 - m. [Viega LLC]
 - n. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. [American Valve, Inc]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [Center Line; a Crane Co. brand]
- d. [DynaQuip Controls]
- e. [Hammond Valve]
- f. [Jenkins Valves; a Crane Co. brand]
- g. [Jomar Valve]
- h. [Lance Valves]
- i. [Milwaukee Valve Company]
- j. [NIBCO INC.]
- k. [Red-White Valve Corp.]
- l. [Stockham; a Crane Co. brand]
- m. [Viega LLC]
- n. <Insert manufacturer's name>

3. Standard: MSS SP-110.
4. SWP Rating: **150 psig (1035 kPa)**.
5. CWP Rating: **600 psig (4140 kPa)**.
6. Body Design: Two piece.
7. Body Material: Bronze.
8. Ends: Threaded.
9. Seats: PTFE.
10. Stem: Bronze.
11. Ball: Chrome-plated brass.
12. Port: Regular.

P. Ball Valves, Threaded Ends - Bronze, Two Piece with Regular Port and Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Center Line; a Crane Co. brand]
 - c. [DynaQuip Controls]
 - d. [Hammond Valve]
 - e. [Jenkins Valves; a Crane Co. brand]
 - f. [Jomar Valve]
 - g. [Milwaukee Valve Company]
 - h. [NIBCO INC.]
 - i. [Red-White Valve Corp.]
 - j. [Stockham; a Crane Co. brand]
 - k. [Viega LLC]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Center Line; a Crane Co. brand]
 - c. [DynaQuip Controls]

- d. [Hammond Valve]
 - e. [Jenkins Valves; a Crane Co. brand]
 - f. [Jomar Valve]
 - g. [Milwaukee Valve Company]
 - h. [NIBCO INC.]
 - i. [Red-White Valve Corp.]
 - j. [Stockham; a Crane Co. brand]
 - k. [Viega LLC]
 - l. <Insert manufacturer's name>
- 3. Standard: MSS SP-110.
 - 4. SWP Rating: **150 psig (1035 kPa)**.
 - 5. CWP Rating: **600 psig (4140 kPa)**.
 - 6. Body Design: Two piece.
 - 7. Body Material: Bronze.
 - 8. Ends: Threaded.
 - 9. Seats: PTFE.
 - 10. Stem: Stainless steel.
 - 11. Ball: Stainless steel, vented.
 - 12. Port: Regular.
- Q. Ball Valves, Threaded Ends - Bronze, Three Piece with Full Port and Bronze or Brass Trim:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [WATTS; A Watts Water Technologies Company]
 - c. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [WATTS; A Watts Water Technologies Company]
 - c. <Insert manufacturer's name>
 - 3. Standard: MSS SP-110.
 - 4. SWP Rating: **150 psig (1035 kPa)**.
 - 5. CWP Rating: **600 psig (4140 kPa)**.
 - 6. Body Design: Three piece.
 - 7. Body Material: Bronze.
 - 8. Ends: Threaded.
 - 9. Seats: PTFE.
 - 10. Stem: Bronze.
 - 11. Ball: Chrome-plated brass.
 - 12. Port: Full.
- R. Ball Valves, Threaded Ends - Bronze, Three Piece with Full Port and Stainless Steel Trim:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
- b. **[DynaQuip Controls]**
- c. **[NIBCO INC.]**
- d. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
- b. **[DynaQuip Controls]**
- c. **[NIBCO INC.]**
- d. **<Insert manufacturer's name>**

3. Standard: MSS SP-110.
4. SWP Rating: **150 psig (1035 kPa)**.
5. CWP Rating: **600 psig (4140 kPa)**.
6. Body Design: Three piece.
7. Body Material: Bronze.
8. Ends: Threaded.
9. Seats: PTFE.
10. Stem: Stainless steel.
11. Ball: Stainless steel, vented.
12. Port: Full.

- S. Ball Valves, Threaded or Soldered Ends - Bronze, Three Piece with Regular Port and Bronze or Brass Trim:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
- b. **[NIBCO INC.]**
- c. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
- b. **[NIBCO INC.]**
- c. **<Insert manufacturer's name>**

3. Standards: MSS SP-110 and MSS SP-145.
4. CWP Rating: **600 psig (4140 kPa)**.
5. Body Design: Three piece.
6. Body Material: Bronze.
7. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
8. Seats: PTFE.
9. Stem: Bronze.
10. Ball: Chrome-plated brass.

11. Port: Regular.
- T. Ball Valves, Threaded or Soldered Ends - Bronze, Three Piece with Regular Port and Stainless Steel Trim:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[NIBCO INC.]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[NIBCO INC.]**
 - c. **<Insert manufacturer's name>**
 3. Standard: MSS SP-110.
 4. SWP Rating: **150 psig (1035 kPa)**.
 5. CWP Rating: **600 psig (4140 kPa)**.
 6. Body Design: Three piece.
 7. Body Material: Bronze.
 8. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
 9. Seats: PTFE.
 10. Stem: Stainless steel.
 11. Ball: Stainless steel, vented.
 12. Port: Regular.
- U. Ball Valves, Flanged Ends - Steel, with Full Port and Stainless Steel Trim, Class 150:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Bray International, Inc.]**
 - c. **[DynaQuip Controls]**
 - d. **[FNW; Ferguson Enterprises, Inc.]**
 - e. **[Hammond Valve]**
 - f. **[Jamesbury; a brand of Valmet]**
 - g. **[Jomar Valve]**
 - h. **[Lance Valves]**
 - i. **[Max-Air Technology Inc.]**
 - j. **[Milwaukee Valve Company]**
 - k. **[NIBCO INC.]**
 - l. **[Stockham; a Crane Co. brand]**
 - m. **[Viega LLC]**
 - n. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
- b. **[Bray International, Inc.]**
- c. **[DynaQuip Controls]**
- d. **[FNW; Ferguson Enterprises, Inc.]**
- e. **[Hammond Valve]**
- f. **[Jamesbury; a brand of Valmet]**
- g. **[Jomar Valve]**
- h. **[Lance Valves]**
- i. **[Max-Air Technology Inc.]**
- j. **[Milwaukee Valve Company]**
- k. **[NIBCO INC.]**
- l. **[Stockham; a Crane Co. brand]**
- m. **[Viega LLC]**
- n. **<Insert manufacturer's name>**

- 3. Standard: MSS SP-72.
- 4. CWP Rating: **285 psig (1964 kPa)**.
- 5. Body Design: Split body.
- 6. Body Material: Carbon steel, ASTM A216/A216M, Type WCB.
- 7. Ends: Flanged.
- 8. Seats: PTFE.
- 9. Stem: Stainless steel.
- 10. Ball: Stainless steel, vented.
- 11. Port: Full.

V. Ball Valves, Flanged Ends - Steel, with Full Port and Stainless Steel Trim, Class 300:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
- b. **[Bray International, Inc.]**
- c. **[DynaQuip Controls]**
- d. **[FNW; Ferguson Enterprises, Inc.]**
- e. **[Hammond Valve]**
- f. **[Jamesbury; a brand of Valmet]**
- g. **[Jomar Valve]**
- h. **[Lance Valves]**
- i. **[Milwaukee Valve Company]**
- j. **[NIBCO INC.]**
- k. **[Stockham; a Crane Co. brand]**
- l. **[Viega LLC]**
- m. **[WATTS; A Watts Water Technologies Company]**
- n. **<Insert manufacturer's name>**

- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**

- b. [Bray International, Inc.]
 - c. [DynaQuip Controls]
 - d. [FNW; Ferguson Enterprises, Inc.]
 - e. [Hammond Valve]
 - f. [Jamesbury; a brand of Valmet]
 - g. [Jomar Valve]
 - h. [Lance Valves]
 - i. [Milwaukee Valve Company]
 - j. [NIBCO INC.]
 - k. [Stockham; a Crane Co. brand]
 - l. [Viega LLC]
 - m. [WATTS; A Watts Water Technologies Company]
 - n. <Insert manufacturer's name>
- 3. Standard: MSS SP-72.
 - 4. CWP Rating: **720 psig (4960 kPa)**.
 - 5. Body Design: Split body.
 - 6. Body Material: Carbon steel, ASTM A216/A216M, Type WCB.
 - 7. Ends: Flanged.
 - 8. Seats: PTFE.
 - 9. Stem: Stainless steel.
 - 10. Ball: Stainless steel, vented.
 - 11. Port: Full.

W. Ball Valves, Flanged Ends - Iron, Class 125:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [American Valve, Inc]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Sure Flow Equipment Inc]
 - d. [WATTS; A Watts Water Technologies Company]
 - e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [American Valve, Inc]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Sure Flow Equipment Inc]
 - d. [WATTS; A Watts Water Technologies Company]
 - e. <Insert manufacturer's name>
- 3. Standard: MSS SP-72.
- 4. CWP Rating: **200 psig (1380 kPa)**.
- 5. Body Design: Split body.
- 6. Body Material: ASTM A126, gray iron.
- 7. Ends: Flanged.
- 8. Seats: PTFE.
- 9. Stem: Stainless steel.
- 10. Ball: Stainless steel.
- 11. Port: Full.

X. Ball Valves, Threaded or Flanged Ends - Stainless Steel, Two Piece with Full Port:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Bray International, Inc.]**
 - d. **[FNW; Ferguson Enterprises, Inc.]**
 - e. **[Guardian Worldwide LLC.]**
 - f. **[Hammond Valve]**
 - g. **[Jomar Valve]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Bray International, Inc.]**
 - d. **[FNW; Ferguson Enterprises, Inc.]**
 - e. **[Guardian Worldwide LLC.]**
 - f. **[Hammond Valve]**
 - g. **[Jomar Valve]**
 - h. **<Insert manufacturer's name>**
3. Standard: MSS SP-110.
4. SWP Rating: **150 psig (1030 kPa)**.
5. WOG Rating: **1000 psig (6895 kPa)**.
6. Body Design: Split body.
7. Body Material: Type 316 stainless steel.
8. Ends: Threaded or flanged. See Part 3 ball valve schedule articles.
9. Seats: PTFE.
10. Stem: Type 316 stainless steel.
11. Ball: Type 316 stainless steel.
12. Port: Full.

Y. Ball Valves - CPVC, Union Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[GF Piping Systems: Georg Fischer LLC]**
 - e. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - f. **[IPEX USA LLC]**
 - g. **[Jomar Valve]**
 - h. **[Red-White Valve Corp.]**

- i. [Spears Manufacturing Company]
 - j. [Thermoplastic Valves, Inc]
 - k. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [GF Piping Systems: Georg Fischer LLC]
 - e. [Hayward Flow Control; Hayward Industries, Inc.]
 - f. [IPEX USA LLC]
 - g. [Jomar Valve]
 - h. [Red-White Valve Corp.]
 - i. [Spears Manufacturing Company]
 - j. [Thermoplastic Valves, Inc]
 - k. <Insert manufacturer's name>
3. Standard: MSS SP-122.
4. Pressure Rating and Temperature: **125 psig (860 kPa), 150 psig (1035 kPa)**, or other pressure at **73 deg F (23 deg C)** or other temperature. See Part 3 ball valve schedule articles.
5. Body Material: CPVC.
6. Body Design: Union type.
7. End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket or threaded. See Part 3 ball valve schedule articles.
8. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable socket, socket or threaded, threaded, or flanged. See Part 3 ball valve schedule articles.
9. Ball: CPVC; full port.
10. Seals: PTFE or EPDM-rubber O-rings.
11. Handle: Tee shaped.
- Z. Ball Valves - CPVC, Non-Union Type:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
- a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [IPEX USA LLC]
 - e. [Jomar Valve]
 - f. [Red-White Valve Corp.]
 - g. [Spears Manufacturing Company]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]



- d. [IPEX USA LLC]
- e. [Jomar Valve]
- f. [Red-White Valve Corp.]
- g. [Spears Manufacturing Company]
- h. <Insert manufacturer's name>

- 3. Standard: MSS SP-122.
- 4. Pressure Rating and Temperature: **125 psig (860 kPa), 150 psig (1035 kPa)**, or other pressure at **73 deg F (23 deg C)** or other temperature. See Part 3 ball valve schedule articles.
- 5. Body Material: CPVC.
- 6. Body Design: Non-union type.
- 7. End Connections: Socket or threaded.
- 8. Ball: CPVC; full or reduced port.
- 9. Seals: PTFE or EPDM-rubber O-rings.
- 10. Handle: Tee shaped.

AA. Ball Valves - PVC, Union Type:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [GF Piping Systems: Georg Fischer LLC]
 - e. [Hayward Flow Control; Hayward Industries, Inc.]
 - f. [IPEX USA LLC]
 - g. [Jomar Valve]
 - h. [Red-White Valve Corp.]
 - i. [Spears Manufacturing Company]
 - j. [Thermoplastic Valves, Inc]
 - k. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [Colonial Engineering, Inc.]
 - d. [GF Piping Systems: Georg Fischer LLC]
 - e. [Hayward Flow Control; Hayward Industries, Inc.]
 - f. [IPEX USA LLC]
 - g. [Jomar Valve]
 - h. [Red-White Valve Corp.]
 - i. [Spears Manufacturing Company]
 - j. [Thermoplastic Valves, Inc]
 - k. <Insert manufacturer's name>
- 3. Standard: MSS SP-122.
- 4. Pressure Rating and Temperature: **125 psig (860 kPa), 150 psig (1035 kPa)**, or other pressure at **73 deg F (23 deg C)** or other temperature. See Part 3 ball valve schedule articles.
- 5. Body Material: PVC.

6. Body Design: Union type.
7. End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket or threaded. See Part 3 ball valve schedule articles.
8. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable union with socket, socket or threaded, threaded, or flanged. See Part 3 ball valve schedule articles.
9. Ball: PVC; full port.
10. Seals: PTFE or EPDM-rubber O-rings.
11. Handle: Tee shaped.

BB. Ball Valves - PVC, Non-Union Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[IPEX USA LLC]**
 - e. **[Jomar Valve]**
 - f. **[Red-White Valve Corp.]**
 - g. **[Spears Manufacturing Company]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[IPEX USA LLC]**
 - e. **[Jomar Valve]**
 - f. **[Red-White Valve Corp.]**
 - g. **[Spears Manufacturing Company]**
 - h. **<Insert manufacturer's name>**
3. Standard: MSS SP-122.
4. Pressure Rating and Temperature: **125 psig (860 kPa), 150 psig (1035 kPa)**, or other pressure at **73 deg F (23 deg C)** or other temperature. See Part 3 ball valve schedule articles.
5. Body Material: PVC.
6. Body Design: Non-union type.
7. End Connections: Socket or threaded.
8. Ball: PVC; full or reduced port.
9. Seals: PTFE or EPDM-rubber O-rings.
10. Handle: Tee shaped.

2.6 BUTTERFLY VALVES

A. Butterfly Valves, Single Flange (Lug Type) - Iron, with Aluminum-Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [ABZ Valve; an ASC Engineered Solution]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [Bray International, Inc.]
- d. [Center Line; a Crane Co. brand]
- e. [DeZURIK]
- f. [DynaQuip Controls]
- g. [Flo Fab Inc]
- h. [Hammond Valve]
- i. [Jamesbury; a brand of Valmet]
- j. [Jenkins Valves; a Crane Co. brand]
- k. [Jomar Valve]
- l. [Kennedy Valve Company; a division of McWane, Inc.]
- m. [KITZ Corporation]
- n. [Lance Valves]
- o. [Legend Valve & Fitting, Inc]
- p. [Milwaukee Valve Company]
- q. [Mueller Steam Specialty; A Watts Water Technologies Company]
- r. [NIBCO INC.]
- s. [Norriseal]
- t. [Red-White Valve Corp.]
- u. [Stockham; a Crane Co. brand]
- v. [Sure Flow Equipment Inc]
- w. [Viega LLC]
- x. [Zurn Industries, LLC]
- y. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [ABZ Valve; an ASC Engineered Solution]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [Bray International, Inc.]
- d. [Center Line; a Crane Co. brand]
- e. [DeZURIK]
- f. [DynaQuip Controls]
- g. [Flo Fab Inc]
- h. [Hammond Valve]
- i. [Jamesbury; a brand of Valmet]
- j. [Jenkins Valves; a Crane Co. brand]
- k. [Jomar Valve]
- l. [Kennedy Valve Company; a division of McWane, Inc.]
- m. [KITZ Corporation]
- n. [Lance Valves]
- o. [Legend Valve & Fitting, Inc]
- p. [Milwaukee Valve Company]
- q. [Mueller Steam Specialty; A Watts Water Technologies Company]
- r. [NIBCO INC.]
- s. [Norriseal]
- t. [Red-White Valve Corp.]
- u. [Stockham; a Crane Co. brand]
- v. [Sure Flow Equipment Inc]
- w. [Viega LLC]

- x. [Zurn Industries, LLC]
 - y. <Insert manufacturer's name>
- 3. Standard: MSS SP-67, Type I.
 - 4. CWP Rating: **150 psig (1035 kPa) or 200 psig (1380 kPa)**. See Part 3 butterfly valve schedule articles.
 - 5. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 6. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
 - 7. Seat: EPDM or NBR. See Part 3 butterfly valve schedule articles.
 - 8. Stem: One- or two-piece stainless steel.
 - 9. Disc: Aluminum bronze.
- B. Butterfly Valves, Single Flange (Lug Type) - Iron, with Ductile-Iron Disc:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [ABZ Valve; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Bray International, Inc.]
 - d. [Center Line; a Crane Co. brand]
 - e. [DeZURIK]
 - f. [DynaQuip Controls]
 - g. [Flo Fab Inc]
 - h. [FNW; Ferguson Enterprises, Inc.]
 - i. [Hammond Valve]
 - j. [Jamesbury; a brand of Valmet]
 - k. [Jenkins Valves; a Crane Co. brand]
 - l. [Jomar Valve]
 - m. [Kennedy Valve Company; a division of McWane, Inc.]
 - n. [KITZ Corporation]
 - o. [Lance Valves]
 - p. [Legend Valve & Fitting, Inc]
 - q. [Milwaukee Valve Company]
 - r. [Mueller Steam Specialty; A Watts Water Technologies Company]
 - s. [NIBCO INC.]
 - t. [Norriseal]
 - u. [Red-White Valve Corp.]
 - v. [Stockham; a Crane Co. brand]
 - w. [Sure Flow Equipment Inc]
 - x. [Viega LLC]
 - y. [Zurn Industries, LLC]
 - z. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [ABZ Valve; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Bray International, Inc.]
 - d. [Center Line; a Crane Co. brand]
 - e. [DeZURIK]

- f. [DynaQuip Controls]
- g. [Flo Fab Inc]
- h. [FNW; Ferguson Enterprises, Inc.]
- i. [Hammond Valve]
- j. [Jamesbury; a brand of Valmet]
- k. [Jenkins Valves; a Crane Co. brand]
- l. [Jomar Valve]
- m. [Kennedy Valve Company; a division of McWane, Inc.]
- n. [KITZ Corporation]
- o. [Lance Valves]
- p. [Legend Valve & Fitting, Inc]
- q. [Milwaukee Valve Company]
- r. [Mueller Steam Specialty; A Watts Water Technologies Company]
- s. [NIBCO INC.]
- t. [Norriseal]
- u. [Red-White Valve Corp.]
- v. [Stockham; a Crane Co. brand]
- w. [Sure Flow Equipment Inc]
- x. [Viega LLC]
- y. [Zurn Industries, LLC]
- z. <Insert manufacturer's name>

- 3. Standard: MSS SP-67, Type I.
- 4. CWP Rating: **150 psig (1035 kPa)** or **200 psig (1380 kPa)**. See Part 3 butterfly valve schedule articles.
- 5. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
- 6. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
- 7. Seat: EPDM or NBR. See Part 3 butterfly valve schedule articles.
- 8. Stem: One- or two-piece stainless steel.
- 9. Disc: Nickel-plated[**or -coated**] ductile iron.

C. Butterfly Valves, Single Flange (Lug Type) - Iron, with Stainless Steel Disc:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [ASC Engineered Solutions]
 - c. [Bray International, Inc.]
 - d. [Center Line; a Crane Co. brand]
 - e. [DeZURIK]
 - f. [DynaQuip Controls]
 - g. [Flo Fab Inc]
 - h. [FNW; Ferguson Enterprises, Inc.]
 - i. [Hammond Valve]
 - j. [Jamesbury; a brand of Valmet]
 - k. [Jenkins Valves; a Crane Co. brand]
 - l. [Jomar Valve]
 - m. [Kennedy Valve Company; a division of McWane, Inc.]
 - n. [KITZ Corporation]
 - o. [Lance Valves]
 - p. [Legend Valve & Fitting, Inc]

- q. [Max-Air Technology Inc.]
 - r. [Milwaukee Valve Company]
 - s. [Mueller Steam Specialty; A Watts Water Technologies Company]
 - t. [NIBCO INC.]
 - u. [Norriseal]
 - v. [Red-White Valve Corp.]
 - w. [Stockham; a Crane Co. brand]
 - x. [Sure Flow Equipment Inc]
 - y. [Viega LLC]
 - z. [Zurn Industries, LLC]
 - aa. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [ASC Engineered Solutions]
 - c. [Bray International, Inc.]
 - d. [Center Line; a Crane Co. brand]
 - e. [DeZURIK]
 - f. [DynaQuip Controls]
 - g. [Flo Fab Inc]
 - h. [FNW; Ferguson Enterprises, Inc.]
 - i. [Hammond Valve]
 - j. [Jamesbury; a brand of Valmet]
 - k. [Jenkins Valves; a Crane Co. brand]
 - l. [Jomar Valve]
 - m. [Kennedy Valve Company; a division of McWane, Inc.]
 - n. [KITZ Corporation]
 - o. [Lance Valves]
 - p. [Legend Valve & Fitting, Inc]
 - q. [Max-Air Technology Inc.]
 - r. [Milwaukee Valve Company]
 - s. [Mueller Steam Specialty; A Watts Water Technologies Company]
 - t. [NIBCO INC.]
 - u. [Norriseal]
 - v. [Red-White Valve Corp.]
 - w. [Stockham; a Crane Co. brand]
 - x. [Sure Flow Equipment Inc]
 - y. [Viega LLC]
 - z. [Zurn Industries, LLC]
 - aa. <Insert manufacturer's name>
- 3. Standard: MSS SP-67, Type I.
 - 4. CWP Rating: **150 psig (1035 kPa)** or **200 psig (1380 kPa)**. See Part 3 butterfly valve schedule articles.
 - 5. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 6. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
 - 7. Seat: EPDM or NBR. See Part 3 butterfly valve schedule articles.
 - 8. Stem: One- or two-piece stainless steel.
 - 9. Disc: Stainless steel.

D. Butterfly Valves, Flangeless (Wafer Type) - Iron, with Aluminum-Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ABZ Valve; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Bray International, Inc.]
 - d. [Center Line; a Crane Co. brand]
 - e. [DeZURIK]
 - f. [DynaQuip Controls]
 - g. [Flo Fab Inc]
 - h. [FNW; Ferguson Enterprises, Inc.]
 - i. [Hammond Valve]
 - j. [Jamesbury; a brand of Valmet]
 - k. [Jenkins Valves; a Crane Co. brand]
 - l. [Jomar Valve]
 - m. [Kennedy Valve Company; a division of McWane, Inc.]
 - n. [KITZ Corporation]
 - o. [Lance Valves]
 - p. [Legend Valve & Fitting, Inc]
 - q. [Milwaukee Valve Company]
 - r. [NIBCO INC.]
 - s. [Norriseal]
 - t. [Red-White Valve Corp.]
 - u. [Stockham; a Crane Co. brand]
 - v. [Sure Flow Equipment Inc]
 - w. [Viega LLC]
 - x. [Zurn Industries, LLC]
 - y. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABZ Valve; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Bray International, Inc.]
 - d. [Center Line; a Crane Co. brand]
 - e. [DeZURIK]
 - f. [DynaQuip Controls]
 - g. [Flo Fab Inc]
 - h. [FNW; Ferguson Enterprises, Inc.]
 - i. [Hammond Valve]
 - j. [Jamesbury; a brand of Valmet]
 - k. [Jenkins Valves; a Crane Co. brand]
 - l. [Jomar Valve]
 - m. [Kennedy Valve Company; a division of McWane, Inc.]
 - n. [KITZ Corporation]
 - o. [Lance Valves]
 - p. [Legend Valve & Fitting, Inc]
 - q. [Milwaukee Valve Company]
 - r. [NIBCO INC.]
 - s. [Norriseal]
 - t. [Red-White Valve Corp.]

- u. [Stockham; a Crane Co. brand]
 - v. [Sure Flow Equipment Inc]
 - w. [Viega LLC]
 - x. [Zurn Industries, LLC]
 - y. <Insert manufacturer's name>
- 3. Standard: MSS SP-67, Type I.
 - 4. CWP Rating: **150 psig (1035 kPa)** or **200 psig (1380 kPa)**. See Part 3 butterfly valve schedule articles.
 - 5. Body Design: Flangeless (wafer type), suitable for bidirectional dead-end service at rated pressure.
 - 6. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
 - 7. Seat: EPDM or NBR. See Part 3 butterfly valve schedule articles.
 - 8. Stem: One- or two-piece stainless steel.
 - 9. Disc: Aluminum bronze.
- E. Butterfly Valves, Flangeless (Wafer Type) - Iron, with Ductile-Iron Disc:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [ABZ Valve; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Bray International, Inc.]
 - d. [Center Line; a Crane Co. brand]
 - e. [DeZURIK]
 - f. [DynaQuip Controls]
 - g. [Flo Fab Inc]
 - h. [FNW; Ferguson Enterprises, Inc.]
 - i. [Hammond Valve]
 - j. [Jamesbury; a brand of Valmet]
 - k. [Jenkins Valves; a Crane Co. brand]
 - l. [Jomar Valve]
 - m. [Kennedy Valve Company; a division of McWane, Inc.]
 - n. [KITZ Corporation]
 - o. [Lance Valves]
 - p. [Legend Valve & Fitting, Inc]
 - q. [Milwaukee Valve Company]
 - r. [NIBCO INC.]
 - s. [Norriseal]
 - t. [Red-White Valve Corp.]
 - u. [Stockham; a Crane Co. brand]
 - v. [Sure Flow Equipment Inc]
 - w. [Viega LLC]
 - x. [Zurn Industries, LLC]
 - y. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [ABZ Valve; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Bray International, Inc.]

- d. [Center Line; a Crane Co. brand]
- e. [DeZURIK]
- f. [DynaQuip Controls]
- g. [Flo Fab Inc]
- h. [FNW; Ferguson Enterprises, Inc.]
- i. [Hammond Valve]
- j. [Jamesbury; a brand of Valmet]
- k. [Jenkins Valves; a Crane Co. brand]
- l. [Jomar Valve]
- m. [Kennedy Valve Company; a division of McWane, Inc.]
- n. [KITZ Corporation]
- o. [Lance Valves]
- p. [Legend Valve & Fitting, Inc]
- q. [Milwaukee Valve Company]
- r. [NIBCO INC.]
- s. [Norriseal]
- t. [Red-White Valve Corp.]
- u. [Stockham; a Crane Co. brand]
- v. [Sure Flow Equipment Inc]
- w. [Viega LLC]
- x. [Zurn Industries, LLC]
- y. <Insert manufacturer's name>

- 3. Standard: MSS SP-67, Type I.
- 4. CWP Rating: **150 psig (1035 kPa)** or **200 psig (1380 kPa)**. See Part 3 butterfly valve schedule articles.
- 5. Body Design: Flangeless (wafer type), suitable for bidirectional dead-end service at rated pressure.
- 6. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
- 7. Seat: EPDM or NBR. See Part 3 butterfly valve schedule articles.
- 8. Stem: One- or two-piece stainless steel.
- 9. Disc: Nickel-plated[**or -coated**] ductile iron.

F. Butterfly Valves, Flangeless (Wafer Type) - Iron, with Stainless Steel Disc:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [ASC Engineered Solutions]
 - c. [Bray International, Inc.]
 - d. [Center Line; a Crane Co. brand]
 - e. [DeZURIK]
 - f. [DynaQuip Controls]
 - g. [Flo Fab Inc]
 - h. [FNW; Ferguson Enterprises, Inc.]
 - i. [Hammond Valve]
 - j. [Jamesbury; a brand of Valmet]
 - k. [Jenkins Valves; a Crane Co. brand]
 - l. [Jomar Valve]
 - m. [Kennedy Valve Company; a division of McWane, Inc.]
 - n. [KITZ Corporation]
 - o. [Lance Valves]

- p. [Legend Valve & Fitting, Inc]
 - q. [Milwaukee Valve Company]
 - r. [NIBCO INC.]
 - s. [Norriseal]
 - t. [Red-White Valve Corp.]
 - u. [Stockham; a Crane Co. brand]
 - v. [Sure Flow Equipment Inc]
 - w. [Viega LLC]
 - x. [Zurn Industries, LLC]
 - y. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [ASC Engineered Solutions]
 - c. [Bray International, Inc.]
 - d. [Center Line; a Crane Co. brand]
 - e. [DeZURIK]
 - f. [DynaQuip Controls]
 - g. [Flo Fab Inc]
 - h. [FNW; Ferguson Enterprises, Inc.]
 - i. [Hammond Valve]
 - j. [Jamesbury; a brand of Valmet]
 - k. [Jenkins Valves; a Crane Co. brand]
 - l. [Jomar Valve]
 - m. [Kennedy Valve Company; a division of McWane, Inc.]
 - n. [KITZ Corporation]
 - o. [Lance Valves]
 - p. [Legend Valve & Fitting, Inc]
 - q. [Milwaukee Valve Company]
 - r. [NIBCO INC.]
 - s. [Norriseal]
 - t. [Red-White Valve Corp.]
 - u. [Stockham; a Crane Co. brand]
 - v. [Sure Flow Equipment Inc]
 - w. [Viega LLC]
 - x. [Zurn Industries, LLC]
 - y. <Insert manufacturer's name>
3. Standard: MSS SP-67, Type I.
4. CWP Rating: **150 psig (1035 kPa)** or **200 psig (1380 kPa)**. See Part 3 butterfly valve schedule articles.
5. Body Design: Flangeless (wafer type), suitable for bidirectional dead-end service at rated pressure.
6. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
7. Seat: EPDM or NBR. See Part 3 butterfly valve schedule articles.
8. Stem: One- or two-piece stainless steel.
9. Disc: Stainless steel.
- G. Butterfly Valves, Grooved End - Ductile Iron, 175 CWP:
- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the

following]:

- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- b. [ASC Engineered Solutions]
- c. [Grinnell G-Fire; brand of Johnson Controls International plc, Building Solutions North America]
- d. [Hammond Valve]
- e. [Kennedy Valve Company; a division of McWane, Inc.]
- f. [NIBCO INC.]
- g. [Norriseal]
- h. [Red-White Valve Corp.]
- i. [Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]
- j. [Vicalic Company]
- k. [Zurn Industries, LLC]
- l. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- b. [ASC Engineered Solutions]
- c. [Grinnell G-Fire; brand of Johnson Controls International plc, Building Solutions North America]
- d. [Hammond Valve]
- e. [Kennedy Valve Company; a division of McWane, Inc.]
- f. [NIBCO INC.]
- g. [Norriseal]
- h. [Red-White Valve Corp.]
- i. [Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]
- j. [Vicalic Company]
- k. [Zurn Industries, LLC]
- l. <Insert manufacturer's name>

- 3. Standard: MSS SP-67, Type I.
- 4. CWP Rating: **175 psig (1200 kPa)**.
- 5. Body Material: Coated, ductile iron.
- 6. Ends: Grooved.
- 7. Stem: Two-piece stainless steel.
- 8. Disc: Coated, ductile iron.
- 9. Seat: EPDM.

H. Butterfly Valves, Grooved End - Ductile Iron, 300 CWP:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [ASC Engineered Solutions]
 - c. [Grinnell G-Fire; brand of Johnson Controls International plc, Building Solutions North America]

- d. [Hammond Valve]
 - e. [Kennedy Valve Company; a division of McWane, Inc.]
 - f. [NIBCO INC.]
 - g. [Norriseal]
 - h. [Red-White Valve Corp.]
 - i. [Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]
 - j. [Victaulic Company]
 - k. [WATTS; A Watts Water Technologies Company]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [ASC Engineered Solutions]
 - c. [Grinnell G-Fire; brand of Johnson Controls International plc, Building Solutions North America]
 - d. [Hammond Valve]
 - e. [Kennedy Valve Company; a division of McWane, Inc.]
 - f. [NIBCO INC.]
 - g. [Norriseal]
 - h. [Red-White Valve Corp.]
 - i. [Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]
 - j. [Victaulic Company]
 - k. [WATTS; A Watts Water Technologies Company]
 - l. <Insert manufacturer's name>
3. Standard: MSS SP-67, Type I.
 4. NPS 8 (DN 50) and Smaller CWP Rating: **300 psig (2070 kPa)**.
 5. Body Material: Coated, ductile iron
 6. Ends: Grooved.
 7. Stem: Two-piece stainless steel.
 8. Disc: Coated, ductile iron.
 9. Seat: EPDM.
- I. Butterfly Valves, Single Flange (Lug Type) - High Performance, Class 150:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [ASC Engineered Solutions]
 - c. [Bray International, Inc.]
 - d. [DeZURIK]
 - e. [Flowseal; Crane Energy Flow Solutions]
 - f. [Hammond Valve]
 - g. [Jamesbury; a brand of Valmet]
 - h. [Lance Valves]
 - i. [Milwaukee Valve Company]
 - j. [Stockham; a Crane Co. brand]
 - k. [XOMOX; Crane ChemPharma & Energy]

- I. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [ASC Engineered Solutions]
 - c. [Bray International, Inc.]
 - d. [DeZURIK]
 - e. [Flowseal; Crane Energy Flow Solutions]
 - f. [Hammond Valve]
 - g. [Jamesbury; a brand of Valmet]
 - h. [Lance Valves]
 - i. [Milwaukee Valve Company]
 - j. [Stockham; a Crane Co. brand]
 - k. [XOMOX; Crane ChemPharma & Energy]
 - l. <Insert manufacturer's name>
3. Standard: MSS SP-68.
4. CWP Rating: **285 psig (1965 kPa) at 100 deg F (38 deg C).**
5. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
6. Body Material: Carbon or stainless steel. See Part 3 butterfly valve schedule articles.
7. Seat: Reinforced PTFE or metal.
8. Stem: Stainless steel; offset from seat plane.
9. Disc: Type 316 stainless steel.
10. Service: Bidirectional.
- J. Butterfly Valves, Single Flange (Lug Type) - High Performance, Class 300:
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ABZ Valve; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Bray International, Inc.]
 - d. [DeZURIK]
 - e. [Flowseal; Crane Energy Flow Solutions]
 - f. [Hammond Valve]
 - g. [Jamesbury; a brand of Valmet]
 - h. [Milwaukee Valve Company]
 - i. [NIBCO INC.]
 - j. [Process Development & Control, Inc.]
 - k. [Stockham; a Crane Co. brand]
 - l. [XOMOX; Crane ChemPharma & Energy]
 - m. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABZ Valve; an ASC Engineered Solution]

- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Bray International, Inc.]
 - d. [DeZURIK]
 - e. [Flowseal; Crane Energy Flow Solutions]
 - f. [Hammond Valve]
 - g. [Jamesbury; a brand of Valmet]
 - h. [Milwaukee Valve Company]
 - i. [NIBCO INC.]
 - j. [Process Development & Control, Inc.]
 - k. [Stockham; a Crane Co. brand]
 - l. [XOMOX; Crane ChemPharma & Energy]
 - m. <Insert manufacturer's name>
- 3. Standard: MSS SP-68.
 - 4. CWP Rating: **720 psig (4965 kPa) at 100 deg F (38 deg C).**
 - 5. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 6. Body Material: Carbon or stainless steel. See Part 3 butterfly valve schedule articles.
 - 7. Seat: Reinforced PTFE or metal.
 - 8. Stem: Stainless steel; offset from seat plane.
 - 9. Disc: Type 316 stainless steel.
 - 10. Service: Bidirectional.

2.7 CHECK VALVES

A. Check Valves, Lift Type, Threaded Ends - Bronze, with Bronze Disc, Class 125:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [A.Y. McDonald Mfg. Co.]
 - b. [American Valve, Inc]
 - c. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - d. [Crane Fluid Systems; Crane Co.]
 - e. [Flomatic Valves; Flomatic Corporation]
 - f. [Jenkins Valves; a Crane Co. brand]
 - g. [Jomar Valve]
 - h. [Keckley Company]
 - i. [Metraflex Company (The)]
 - j. [Milwaukee Valve Company]
 - k. [NIBCO INC.]
 - l. [Stockham; a Crane Co. brand]
 - m. [Val-Matic Valve & Manufacturing Corp.]
 - n. [Victaulic Company]
 - o. [WATTS; A Watts Water Technologies Company]
 - p. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [A.Y. McDonald Mfg. Co.]
 - b. [American Valve, Inc]

- c. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- d. [Crane Fluid Systems; Crane Co.]
- e. [Flomatic Valves; Flomatic Corporation]
- f. [Jenkins Valves; a Crane Co. brand]
- g. [Jomar Valve]
- h. [Keckley Company]
- i. [Metraflex Company (The)]
- j. [Milwaukee Valve Company]
- k. [NIBCO INC.]
- l. [Stockham; a Crane Co. brand]
- m. [Val-Matic Valve & Manufacturing Corp.]
- n. [Victaulic Company]
- o. [WATTS; A Watts Water Technologies Company]
- p. <Insert manufacturer's name>

- 3. Standard: MSS SP-80, Type 1.
- 4. CWP Rating: **200 psig (1380 kPa)**.
- 5. Body Design: Vertical flow.
- 6. Body Material: ASTM B61 or ASTM B62, bronze.
- 7. Ends: Threaded.
- 8. Disc: Bronze.

B. Check Valves, Lift Type, Threaded Ends - Bronze, with Nonmetallic Disc, Class 125:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Crane Fluid Systems; Crane Co.]
 - b. [Jenkins Valves; a Crane Co. brand]
 - c. [Jomar Valve]
 - d. [Keckley Company]
 - e. [Lance Valves]
 - f. [Milwaukee Valve Company]
 - g. [NIBCO INC.]
 - h. [Red-White Valve Corp.]
 - i. [Shurjoint; a part of Aalberts Integrated Piping Systems]
 - j. [Stockham; a Crane Co. brand]
 - k. [Val-Matic Valve & Manufacturing Corp.]
 - l. [Victaulic Company]
 - m. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Crane Fluid Systems; Crane Co.]
 - b. [Jenkins Valves; a Crane Co. brand]
 - c. [Jomar Valve]
 - d. [Keckley Company]
 - e. [Lance Valves]
 - f. [Milwaukee Valve Company]
 - g. [NIBCO INC.]
 - h. [Red-White Valve Corp.]

- i. [Shurjoint; a part of Aalberts Integrated Piping Systems]
 - j. [Stockham; a Crane Co. brand]
 - k. [Val-Matic Valve & Manufacturing Corp.]
 - l. [Victaulic Company]
 - m. <Insert manufacturer's name>
- 3. Standard: MSS SP-80, Type 2.
 - 4. CWP Rating: **200 psig (1380 kPa)**.
 - 5. Body Design: Vertical flow.
 - 6. Body Material: ASTM B61 or ASTM B62, bronze.
 - 7. Ends: Threaded.
 - 8. Disc: NBR or PTFE.
- C. Check Valves, Swing Type, Threaded Ends - Bronze, with Bronze Disc, Class 125:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Crane Fluid Systems; Crane Co.]
 - c. [Jenkins Valves; a Crane Co. brand]
 - d. [Jomar Valve]
 - e. [Keckley Company]
 - f. [Lance Valves]
 - g. [Milwaukee Valve Company]
 - h. [NIBCO INC.]
 - i. [Red-White Valve Corp.]
 - j. [Shurjoint; a part of Aalberts Integrated Piping Systems]
 - k. [Stockham; a Crane Co. brand]
 - l. [Val-Matic Valve & Manufacturing Corp.]
 - m. [Victaulic Company]
 - n. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Crane Fluid Systems; Crane Co.]
 - c. [Jenkins Valves; a Crane Co. brand]
 - d. [Jomar Valve]
 - e. [Keckley Company]
 - f. [Lance Valves]
 - g. [Milwaukee Valve Company]
 - h. [NIBCO INC.]
 - i. [Red-White Valve Corp.]
 - j. [Shurjoint; a part of Aalberts Integrated Piping Systems]
 - k. [Stockham; a Crane Co. brand]
 - l. [Val-Matic Valve & Manufacturing Corp.]
 - m. [Victaulic Company]
 - n. <Insert manufacturer's name>
 - 3. Standard: MSS SP-80, Type 3.
 - 4. CWP Rating: **200 psig (1380 kPa)**.

5. Body Design: Horizontal flow.
6. Body Material: ASTM B62, bronze.
7. Ends: Threaded.
8. Disc: Bronze.

D. Check Valves, Swing Type, Threaded Ends - Bronze, with Nonmetallic Disc, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Jenkins Valves; a Crane Co. brand]**
 - d. **[Jomar Valve]**
 - e. **[Keckley Company]**
 - f. **[Lance Valves]**
 - g. **[Milwaukee Valve Company]**
 - h. **[NIBCO INC.]**
 - i. **[Powell Valves]**
 - j. **[Red-White Valve Corp.]**
 - k. **[Stockham; a Crane Co. brand]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Jenkins Valves; a Crane Co. brand]**
 - d. **[Jomar Valve]**
 - e. **[Keckley Company]**
 - f. **[Lance Valves]**
 - g. **[Milwaukee Valve Company]**
 - h. **[NIBCO INC.]**
 - i. **[Powell Valves]**
 - j. **[Red-White Valve Corp.]**
 - k. **[Stockham; a Crane Co. brand]**
 - l. **<Insert manufacturer's name>**
3. Standard: MSS SP-80, Type 4.
4. CWP Rating: **200 psig (1380 kPa)**.
5. Body Design: Horizontal flow.
6. Body Material: ASTM B62, bronze.
7. Ends: Threaded.
8. Disc: PTFE.

E. Check Valves, Swing Type, Threaded Ends - Bronze, with Bronze Disc, Class 150:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. [A.Y. McDonald Mfg. Co.]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Crane Fluid Systems; Crane Co.]
 - d. [Hammond Valve]
 - e. [Jenkins Valves; a Crane Co. brand]
 - f. [Jomar Valve]
 - g. [Lance Valves]
 - h. [Legend Valve & Fitting, Inc]
 - i. [Milwaukee Valve Company]
 - j. [NIBCO INC.]
 - k. [Powell Valves]
 - l. [Red-White Valve Corp.]
 - m. [Stockham; a Crane Co. brand]
 - n. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [A.Y. McDonald Mfg. Co.]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Crane Fluid Systems; Crane Co.]
 - d. [Hammond Valve]
 - e. [Jenkins Valves; a Crane Co. brand]
 - f. [Jomar Valve]
 - g. [Lance Valves]
 - h. [Legend Valve & Fitting, Inc]
 - i. [Milwaukee Valve Company]
 - j. [NIBCO INC.]
 - k. [Powell Valves]
 - l. [Red-White Valve Corp.]
 - m. [Stockham; a Crane Co. brand]
 - n. <Insert manufacturer's name>
3. Standard: MSS SP-80, Type 3.
4. CWP Rating: **300 psig (2070 kPa)**.
5. Body Design: Horizontal flow.
6. Body Material: ASTM B62, bronze.
7. Ends: Threaded.
8. Disc: Bronze.
- F. Check Valves, Swing Type, Threaded Ends - Bronze, with Nonmetallic Disc, Class 150:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Crane Fluid Systems; Crane Co.]
 - b. [Jenkins Valves; a Crane Co. brand]
 - c. [Jomar Valve]
 - d. [Lance Valves]
 - e. [Milwaukee Valve Company]
 - f. [NIBCO INC.]
 - g. [Powell Valves]
 - h. [Red-White Valve Corp.]

- i. **[Stockham; a Crane Co. brand]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Crane Fluid Systems; Crane Co.]**
 - b. **[Jenkins Valves; a Crane Co. brand]**
 - c. **[Jomar Valve]**
 - d. **[Lance Valves]**
 - e. **[Milwaukee Valve Company]**
 - f. **[NIBCO INC.]**
 - g. **[Powell Valves]**
 - h. **[Red-White Valve Corp.]**
 - i. **[Stockham; a Crane Co. brand]**
 - j. **<Insert manufacturer's name>**
3. Standard: MSS SP-80, Type 4.
4. CWP Rating: **300 psig (2070 kPa)**.
5. Body Design: Horizontal flow.
6. Body Material: ASTM B62, bronze.
7. Ends: Threaded.
8. Disc: PTFE.

G. Check Valves, Swing Type, Press Ends - Bronze:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]**
 - d. **[Hammond Valve]**
 - e. **[Legend Valve & Fitting, Inc]**
 - f. **[Milwaukee Valve Company]**
 - g. **[NIBCO INC.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]**
 - d. **[Hammond Valve]**
 - e. **[Legend Valve & Fitting, Inc]**
 - f. **[Milwaukee Valve Company]**
 - g. **[NIBCO INC.]**
 - h. **<Insert manufacturer's name>**
3. Standard: MSS SP-80.

4. CWP Rating: Minimum **200 psig (1380 kPa)**.
5. Body Design: Horizontal flow.
6. Body Material: ASTM B584, bronze.
7. Ends: Press.
8. Press Ends Connection Rating: Minimum **200 psig (1380 kPa)**.
9. Disc: Brass or bronze.

H. Check Valves, Swing Type, Flanged Ends - Iron, with Metal Seats, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Bray International, Inc.]**
 - d. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - e. **[Cooper Valves]**
 - f. **[Crane Fluid Systems; Crane Co.]**
 - g. **[DeZURIK]**
 - h. **[FNW; Ferguson Enterprises, Inc.]**
 - i. **[GA Industries, Inc]**
 - j. **[Hammond Valve]**
 - k. **[Jenkins Valves; a Crane Co. brand]**
 - l. **[Jomar Valve]**
 - m. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - n. **[KITZ Corporation]**
 - o. **[Lance Valves]**
 - p. **[Milwaukee Valve Company]**
 - q. **[Powell Valves]**
 - r. **[Victaulic Company]**
 - s. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Bray International, Inc.]**
 - d. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - e. **[Cooper Valves]**
 - f. **[Crane Fluid Systems; Crane Co.]**
 - g. **[DeZURIK]**
 - h. **[FNW; Ferguson Enterprises, Inc.]**
 - i. **[GA Industries, Inc]**
 - j. **[Hammond Valve]**
 - k. **[Jenkins Valves; a Crane Co. brand]**
 - l. **[Jomar Valve]**
 - m. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - n. **[KITZ Corporation]**
 - o. **[Lance Valves]**
 - p. **[Milwaukee Valve Company]**
 - q. **[Powell Valves]**
 - r. **[Victaulic Company]**

s. <Insert manufacturer's name>

3. Standard: MSS SP-71, Type I.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa).**
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa).**
6. Body Design: Clear or full waterway.
7. Body Material: ASTM A126, gray iron with bolted bonnet.
8. Ends: Flanged.
9. Trim: Bronze.
10. Gasket: Asbestos free.

I. Check Valves, Swing Type, Flanged Ends - Iron, with Nonmetallic-to-Metal Seats, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Bray International, Inc.]**
 - b. **[Cooper Valves]**
 - c. **[Crane Fluid Systems; Crane Co.]**
 - d. **[DeZURIK]**
 - e. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - f. **[KITZ Corporation]**
 - g. **[Lance Valves]**
 - h. **[Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]**
 - i. **[Victaulic Company]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bray International, Inc.]**
 - b. **[Cooper Valves]**
 - c. **[Crane Fluid Systems; Crane Co.]**
 - d. **[DeZURIK]**
 - e. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - f. **[KITZ Corporation]**
 - g. **[Lance Valves]**
 - h. **[Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]**
 - i. **[Victaulic Company]**
 - j. **<Insert manufacturer's name>**
3. Standard: MSS SP-71, Type I.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa).**
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa).**
6. Body Design: Clear or full waterway.
7. Body Material: ASTM A126, gray iron with bolted bonnet.
8. Ends: Flanged.
9. Trim: Composition.
10. Seat Ring: Bronze.
11. Disc Holder: Bronze.

12. Disc: PTFE.
 13. Gasket: Asbestos free.
- J. Check Valves, Swing Type, Flanged Ends - Iron, with Metal Seats, Class 250:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Bray International, Inc.]**
 - c. **[Cooper Valves]**
 - d. **[Crane Fluid Systems; Crane Co.]**
 - e. **[Crispin Valve]**
 - f. **[DeZURIK]**
 - g. **[FNW; Ferguson Enterprises, Inc.]**
 - h. **[GA Industries, Inc]**
 - i. **[Hammond Valve]**
 - j. **[Jenkins Valves; a Crane Co. brand]**
 - k. **[KITZ Corporation]**
 - l. **[Lance Valves]**
 - m. **[Milwaukee Valve Company]**
 - n. **[Powell Valves]**
 - o. **[Victaulic Company]**
 - p. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Bray International, Inc.]**
 - c. **[Cooper Valves]**
 - d. **[Crane Fluid Systems; Crane Co.]**
 - e. **[Crispin Valve]**
 - f. **[DeZURIK]**
 - g. **[FNW; Ferguson Enterprises, Inc.]**
 - h. **[GA Industries, Inc]**
 - i. **[Hammond Valve]**
 - j. **[Jenkins Valves; a Crane Co. brand]**
 - k. **[KITZ Corporation]**
 - l. **[Lance Valves]**
 - m. **[Milwaukee Valve Company]**
 - n. **[Powell Valves]**
 - o. **[Victaulic Company]**
 - p. **<Insert manufacturer's name>**
 3. Standard: MSS SP-71, Type I.
 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **500 psig (3450 kPa).**
 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **300 psig (2070 kPa).**
 6. Body Design: Clear or full waterway.
 7. Body Material: ASTM A126, gray iron with bolted bonnet.
 8. Ends: Flanged.
 9. Trim: Bronze.
 10. Gasket: Asbestos free.

K. Check Valves, Swing Type, Flanged Ends - Iron, with Lever- and Spring-Closure Control, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Bray International, Inc.]**
 - c. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - d. **[Cooper Valves]**
 - e. **[Crispin Valve]**
 - f. **[DeZURIK]**
 - g. **[GA Industries, Inc]**
 - h. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Bray International, Inc.]**
 - c. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - d. **[Cooper Valves]**
 - e. **[Crispin Valve]**
 - f. **[DeZURIK]**
 - g. **[GA Industries, Inc]**
 - h. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - i. **<Insert manufacturer's name>**
3. Standard: MSS SP-71, Type I.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa)**.
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa)**.
6. Body Design: Clear or full waterway.
7. Body Material: ASTM A126, gray iron with bolted bonnet.
8. Ends: Flanged.
9. Trim: Bronze.
10. Gasket: Asbestos free.
11. Closure Control: Factory-installed, exterior lever and spring.

L. Check Valves, Swing Type, Flanged Ends - Iron, with Lever- and Weight-Closure Control, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[ASC Engineered Solutions]**
 - c. **[Bray International, Inc.]**
 - d. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - e. **[Cooper Valves]**
 - f. **[Crispin Valve]**
 - g. **[DeZURIK]**

- h. **[GA Industries, Inc]**
 - i. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - j. **[Milwaukee Valve Company]**
 - k. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[ASC Engineered Solutions]**
 - c. **[Bray International, Inc.]**
 - d. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - e. **[Cooper Valves]**
 - f. **[Crispin Valve]**
 - g. **[DeZURIK]**
 - h. **[GA Industries, Inc]**
 - i. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - j. **[Milwaukee Valve Company]**
 - k. **<Insert manufacturer's name>**
 - 3. Standard: MSS SP-71, Type I.
 - 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa)**.
 - 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa)**.
 - 6. Body Design: Clear or full waterway.
 - 7. Body Material: ASTM A126, gray iron with bolted bonnet.
 - 8. Ends: Flanged.
 - 9. Trim: Bronze.
 - 10. Gasket: Asbestos free.
 - 11. Closure Control: Factory-installed, exterior lever and weight.
- M. Check Valves, Swing Type, Grooved End - Iron, 300 CWP:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[ASC Engineered Solutions]**
 - d. **[DeZURIK]**
 - e. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - f. **[Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]**
 - g. **[Victaulic Company]**
 - h. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[ASC Engineered Solutions]**
 - d. **[DeZURIK]**

- e. [Shurjoint; a part of Aalberts Integrated Piping Systems]
 - f. [Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]
 - g. [Victaulic Company]
 - h. <Insert manufacturer's name>
- 3. CWP Rating: **300 psig (2070 kPa)**.
 - 4. Body Material: ASTM A536, ductile iron.
 - 5. Seat: EPDM.
 - 6. Disc: Spring operated, ductile iron or stainless steel.

N. Check Valves, Center Guided - Iron, Compact Wafer, with Metal Seat, Class 125:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Anvil; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Cooper Valves]
 - d. [Crispin Valve]
 - e. [DeZURIK]
 - f. [DFT Inc.]
 - g. [Flomatic Valves; Flomatic Corporation]
 - h. [GA Industries, Inc]
 - i. [Keckley Company]
 - j. [KITZ Corporation]
 - k. [Metraflex Company (The)]
 - l. [Milwaukee Valve Company]
 - m. [Val-Matic Valve & Manufacturing Corp.]
 - n. [Victaulic Company]
 - o. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Anvil; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Cooper Valves]
 - d. [Crispin Valve]
 - e. [DeZURIK]
 - f. [DFT Inc.]
 - g. [Flomatic Valves; Flomatic Corporation]
 - h. [GA Industries, Inc]
 - i. [Keckley Company]
 - j. [KITZ Corporation]
 - k. [Metraflex Company (The)]
 - l. [Milwaukee Valve Company]
 - m. [Val-Matic Valve & Manufacturing Corp.]
 - n. [Victaulic Company]
 - o. <Insert manufacturer's name>
- 3. Standard: MSS SP-125.

4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa).**
 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa).**
 6. Body Material: ASTM A126, gray iron.
 7. Style: Compact wafer.
 8. Seat: Bronze.
- O. Check Valves, Center Guided - Iron, Globe, with Metal Seat, Class 125:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ASC Engineered Solutions]**
 - b. **[Crispin Valve]**
 - c. **[DFT Inc.]**
 - d. **[Flomatic Valves; Flomatic Corporation]**
 - e. **[GA Industries, Inc]**
 - f. **[KITZ Corporation]**
 - g. **[Metraflex Company (The)]**
 - h. **[Milwaukee Valve Company]**
 - i. **[Val-Matic Valve & Manufacturing Corp.]**
 - j. **[WATTS; A Watts Water Technologies Company]**
 - k. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ASC Engineered Solutions]**
 - b. **[Crispin Valve]**
 - c. **[DFT Inc.]**
 - d. **[Flomatic Valves; Flomatic Corporation]**
 - e. **[GA Industries, Inc]**
 - f. **[KITZ Corporation]**
 - g. **[Metraflex Company (The)]**
 - h. **[Milwaukee Valve Company]**
 - i. **[Val-Matic Valve & Manufacturing Corp.]**
 - j. **[WATTS; A Watts Water Technologies Company]**
 - k. **<Insert manufacturer's name>**
 3. Standard: MSS SP-125.
 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa).**
 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa).**
 6. Body Material: ASTM A126, gray iron.
 7. Style: Globe, spring loaded.
 8. Ends: Flanged.
 9. Seat: Bronze.
- P. Check Valves, Center Guided - Iron, Compact Wafer, with Metal Seat, Class 150:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. [Anvil; an ASC Engineered Solution]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [Cooper Valves]
- d. [Crispin Valve]
- e. [DeZURIK]
- f. [DFT Inc.]
- g. [Flomatic Valves; Flomatic Corporation]
- h. [GA Industries, Inc]
- i. [Keckley Company]
- j. [KITZ Corporation]
- k. [Metraflex Company (The)]
- l. [Victaulic Company]
- m. [WATTS; A Watts Water Technologies Company]
- n. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Anvil; an ASC Engineered Solution]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [Cooper Valves]
- d. [Crispin Valve]
- e. [DeZURIK]
- f. [DFT Inc.]
- g. [Flomatic Valves; Flomatic Corporation]
- h. [GA Industries, Inc]
- i. [Keckley Company]
- j. [KITZ Corporation]
- k. [Metraflex Company (The)]
- l. [Victaulic Company]
- m. [WATTS; A Watts Water Technologies Company]
- n. <Insert manufacturer's name>

- 3. Standard: MSS SP-125.
- 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **300 psig (2070 kPa)**.
- 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **250 psig (1725 kPa)**.
- 6. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
- 7. Style: Compact wafer.
- 8. Seat: Bronze.

- Q. Check Valves, Center Guided - Iron, Globe, with Metal Seat, Class 150:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [Crispin Valve]
- b. [DFT Inc.]
- c. [Flomatic Valves; Flomatic Corporation]
- d. [GA Industries, Inc]
- e. [KITZ Corporation]
- f. [Metraflex Company (The)]
- g. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crispin Valve]**
 - b. **[DFT Inc.]**
 - c. **[Flomatic Valves; Flomatic Corporation]**
 - d. **[GA Industries, Inc]**
 - e. **[KITZ Corporation]**
 - f. **[Metraflex Company (The)]**
 - g. **<Insert manufacturer's name>**
3. Standard: MSS SP-125.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **300 psig (2070 kPa).**
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **250 psig (1725 kPa).**
6. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
7. Style: Globe, spring loaded.
8. Ends: Flanged.
9. Seat: Bronze.

R. Check Valves, Center Guided - Iron, Compact Wafer, with Metal Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Cooper Valves]**
 - c. **[DeZURIK]**
 - d. **[DFT Inc.]**
 - e. **[Flomatic Valves; Flomatic Corporation]**
 - f. **[Keckley Company]**
 - g. **[Metraflex Company (The)]**
 - h. **[Val-Matic Valve & Manufacturing Corp.]**
 - i. **[Victaulic Company]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Cooper Valves]**
 - c. **[DeZURIK]**
 - d. **[DFT Inc.]**
 - e. **[Flomatic Valves; Flomatic Corporation]**
 - f. **[Keckley Company]**
 - g. **[Metraflex Company (The)]**
 - h. **[Val-Matic Valve & Manufacturing Corp.]**
 - i. **[Victaulic Company]**
 - j. **<Insert manufacturer's name>**
3. Standard: MSS SP-125.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **400 psig (2760 kPa).**
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **300 psig (2070 kPa).**



6. Body Material: ASTM A126, gray iron.
7. Style: Compact wafer, spring loaded.
8. Seat: Bronze.

S. Check Valves, Center Guided - Iron, Globe, with Metal Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[DFT Inc.]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[Metraflex Company (The)]**
 - d. **[Val-Matic Valve & Manufacturing Corp.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[DFT Inc.]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[Metraflex Company (The)]**
 - d. **[Val-Matic Valve & Manufacturing Corp.]**
 - e. **<Insert manufacturer's name>**
3. Standard: MSS SP-125.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **400 psig (2760 kPa).**
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **300 psig (2070 kPa).**
6. Body Material: ASTM A126, gray iron.
7. Style: Globe, spring loaded.
8. Ends: Flanged.
9. Seat: Bronze.

T. Check Valves, Center Guided - Iron, Compact Wafer, with Metal Seat, Class 300:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Cooper Valves]**
 - c. **[Crispin Valve]**
 - d. **[DFT Inc.]**
 - e. **[Flomatic Valves; Flomatic Corporation]**
 - f. **[Keckley Company]**
 - g. **[Metraflex Company (The)]**
 - h. **[Victaulic Company]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Anvil; an ASC Engineered Solution]
 - b. [Cooper Valves]
 - c. [Crispin Valve]
 - d. [DFT Inc.]
 - e. [Flomatic Valves; Flomatic Corporation]
 - f. [Keckley Company]
 - g. [Metraflex Company (The)]
 - h. [Victaulic Company]
 - i. <Insert manufacturer's name>
 3. Standard: MSS SP-125.
 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **500 psig (3450 kPa)**.
 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **400 psig (2760 kPa)**.
 6. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
 7. Style: Compact wafer, spring loaded.
 8. Seat: Bronze.
- U. Check Valves, Center Guided - Iron, Globe, with Metal Seat, Class 300:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Crispin Valve]
 - b. [DFT Inc.]
 - c. [Metraflex Company (The)]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Crispin Valve]
 - b. [DFT Inc.]
 - c. [Metraflex Company (The)]
 - d. <Insert manufacturer's name>
 3. Standard: MSS SP-125.
 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **500 psig (3450 kPa)**.
 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **400 psig (2760 kPa)**.
 6. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
 7. Style: Globe, spring loaded.
 8. Ends: Flanged.
 9. Seat: Bronze.
- V. Check Valves, Center Guided - Iron, Compact Wafer, with Resilient Seat, Class 125:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Cooper Valves]
 - c. [DeZURIK]

- d. [DFT Inc.]
- e. [Flomatic Valves; Flomatic Corporation]
- f. [Val-Matic Valve & Manufacturing Corp.]
- g. [Victaulic Company]
- h. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- b. [Cooper Valves]
- c. [DeZURIK]
- d. [DFT Inc.]
- e. [Flomatic Valves; Flomatic Corporation]
- f. [Val-Matic Valve & Manufacturing Corp.]
- g. [Victaulic Company]
- h. <Insert manufacturer's name>

- 3. Standard: MSS SP-125.
- 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa)**.
- 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa)**.
- 6. Body Material: ASTM A126, gray iron.
- 7. Style: Compact wafer.
- 8. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

W. Check Valves, Center Guided - Iron, Globe, with Resilient Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. [DFT Inc.]
- b. [Flomatic Valves; Flomatic Corporation]
- c. [Val-Matic Valve & Manufacturing Corp.]
- d. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [DFT Inc.]
- b. [Flomatic Valves; Flomatic Corporation]
- c. [Val-Matic Valve & Manufacturing Corp.]
- d. <Insert manufacturer's name>

- 3. Standard: MSS SP-125.
- 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa)**.
- 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa)**.
- 6. Body Material: ASTM A126, gray iron.
- 7. Style: Globe, spring loaded.
- 8. Ends: Flanged.
- 9. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

- X. Check Valves, Center Guided - Iron, Compact Wafer, with Resilient Seat, Class 150:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Cooper Valves]**
 - b. **[DeZURIK]**
 - c. **[DFT Inc.]**
 - d. **[Flomatic Valves; Flomatic Corporation]**
 - e. **[GA Industries, Inc]**
 - f. **[Val-Matic Valve & Manufacturing Corp.]**
 - g. **[VICTAULIC Company]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cooper Valves]**
 - b. **[DeZURIK]**
 - c. **[DFT Inc.]**
 - d. **[Flomatic Valves; Flomatic Corporation]**
 - e. **[GA Industries, Inc]**
 - f. **[Val-Matic Valve & Manufacturing Corp.]**
 - g. **[VICTAULIC Company]**
 - h. **<Insert manufacturer's name>**
 3. Standard: MSS SP-125.
 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **300 psig (2070 kPa).**
 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **250 psig (1725 kPa).**
 6. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
 7. Style: Compact wafer.
 8. Seat: EPDM or NBR. See Part 3 check valve schedule articles.
- Y. Check Valves, Center Guided - Iron, Globe, with Resilient Seat, Class 150:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[DFT Inc.]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[Val-Matic Valve & Manufacturing Corp.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[DFT Inc.]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[Val-Matic Valve & Manufacturing Corp.]**
 - d. **<Insert manufacturer's name>**

3. Standard: MSS SP-125.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **300 psig (2070 kPa)**.
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **250 psig (1725 kPa)**.
6. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
7. Style: Globe, spring loaded.
8. Ends: Flanged.
9. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

Z. Check Valves, Center Guided - Iron, Compact Wafer, with Resilient Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Cooper Valves]**
 - b. **[DeZURIK]**
 - c. **[DFT Inc.]**
 - d. **[Flomatic Valves; Flomatic Corporation]**
 - e. **[Val-Matic Valve & Manufacturing Corp.]**
 - f. **[Victaulic Company]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cooper Valves]**
 - b. **[DeZURIK]**
 - c. **[DFT Inc.]**
 - d. **[Flomatic Valves; Flomatic Corporation]**
 - e. **[Val-Matic Valve & Manufacturing Corp.]**
 - f. **[Victaulic Company]**
 - g. **<Insert manufacturer's name>**
3. Standard: MSS SP-125.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **400 psig (2760 kPa)**.
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **300 psig (2070 kPa)**.
6. Body Material: ASTM A126, gray iron.
7. Style: Compact wafer, spring loaded.
8. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

AA. Check Valves, Center Guided - Iron, Globe, with Resilient Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[DFT Inc.]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[Val-Matic Valve & Manufacturing Corp.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[DFT Inc.]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[Val-Matic Valve & Manufacturing Corp.]**
 - d. **<Insert manufacturer's name>**
3. Standard: MSS SP-125.
 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **400 psig (2760 kPa)**.
 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **300 psig (2070 kPa)**.
 6. Body Material: ASTM A126, gray iron.
 7. Style: Globe, spring loaded.
 8. Ends: Flanged.
 9. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

BB. Check Valves, Center Guided - Iron, Compact Wafer, with Resilient Seat, Class 300:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Cooper Valves]**
 - b. **[DeZURIK]**
 - c. **[DFT Inc.]**
 - d. **[Flomatic Valves; Flomatic Corporation]**
 - e. **[Victaulic Company]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cooper Valves]**
 - b. **[DeZURIK]**
 - c. **[DFT Inc.]**
 - d. **[Flomatic Valves; Flomatic Corporation]**
 - e. **[Victaulic Company]**
 - f. **<Insert manufacturer's name>**
3. Standard: MSS SP-125.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **500 psig (3450 kPa)**.
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **400 psig (2760 kPa)**.
6. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
7. Style: Compact wafer, spring loaded.
8. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

CC. Check Valves, Center Guided - Iron, Globe, with Resilient Seat, Class 300:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[DFT Inc.]**

- b. [Flomatic Valves; Flomatic Corporation]
- c. [Shurjoint; a part of Aalberts Integrated Piping Systems]
- d. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [DFT Inc.]
- b. [Flomatic Valves; Flomatic Corporation]
- c. [Shurjoint; a part of Aalberts Integrated Piping Systems]
- d. <Insert manufacturer's name>

- 3. Standard: MSS SP-125.
- 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **500 psig (3450 kPa).**
- 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **400 psig (2760 kPa).**
- 6. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
- 7. Style: Globe, spring loaded.
- 8. Ends: Flanged.
- 9. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

DD. Check Valves, Dual-Plate Type - Iron, with Metal Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [ABZ Valve; an ASC Engineered Solution]
- b. [Anvil; an ASC Engineered Solution]
- c. [Bray International, Inc.]
- d. [DeZURIK]
- e. [Flomatic Valves; Flomatic Corporation]
- f. [Jomar Valve]
- g. [Keckley Company]
- h. [Lance Valves]
- i. [Legend Valve & Fitting, Inc]
- j. [Metraflex Company (The)]
- k. [Shurjoint; a part of Aalberts Integrated Piping Systems]
- l. [Stockham; a Crane Co. brand]
- m. [Sure Flow Equipment Inc]
- n. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [ABZ Valve; an ASC Engineered Solution]
- b. [Anvil; an ASC Engineered Solution]
- c. [Bray International, Inc.]
- d. [DeZURIK]
- e. [Flomatic Valves; Flomatic Corporation]
- f. [Jomar Valve]
- g. [Keckley Company]
- h. [Lance Valves]

- i. [Legend Valve & Fitting, Inc]
 - j. [Metraflex Company (The)]
 - k. [Shurjoint; a part of Aalberts Integrated Piping Systems]
 - l. [Stockham; a Crane Co. brand]
 - m. [Sure Flow Equipment Inc]
 - n. <Insert manufacturer's name>
- 3. Standard: API 594.
 - 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa)**.
 - 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa)**.
 - 6. Body Design: Wafer, spring-loaded plates.
 - 7. Body Material: ASTM A126, gray iron.
 - 8. Seat: Bronze.

EE. Check Valves, Dual-Plate Type - Iron, with Metal Seat, Class 150:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [ABZ Valve; an ASC Engineered Solution]
 - b. [Anvil; an ASC Engineered Solution]
 - c. [Bray International, Inc.]
 - d. [DeZURIK]
 - e. [Jomar Valve]
 - f. [Keckley Company]
 - g. [Lance Valves]
 - h. [Legend Valve & Fitting, Inc]
 - i. [Metraflex Company (The)]
 - j. [Stockham; a Crane Co. brand]
 - k. [Sure Flow Equipment Inc]
 - l. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [ABZ Valve; an ASC Engineered Solution]
 - b. [Anvil; an ASC Engineered Solution]
 - c. [Bray International, Inc.]
 - d. [DeZURIK]
 - e. [Jomar Valve]
 - f. [Keckley Company]
 - g. [Lance Valves]
 - h. [Legend Valve & Fitting, Inc]
 - i. [Metraflex Company (The)]
 - j. [Stockham; a Crane Co. brand]
 - k. [Sure Flow Equipment Inc]
 - l. <Insert manufacturer's name>
- 3. Standard: API 594.
- 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **300 psig (2070 kPa)**.
- 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **250 psig (1725 kPa)**.
- 6. Body Design: Wafer, spring-loaded plates.
- 7. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.

8. Seat: Bronze.

FF. Check Valves, Dual-Plate Type - Iron, with Metal Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABZ Valve; an ASC Engineered Solution]**
 - b. **[Anvil; an ASC Engineered Solution]**
 - c. **[Bray International, Inc.]**
 - d. **[Keckley Company]**
 - e. **[Stockham; a Crane Co. brand]**
 - f. **[Sure Flow Equipment Inc]**
 - g. **[Val-Matic Valve & Manufacturing Corp.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABZ Valve; an ASC Engineered Solution]**
 - b. **[Anvil; an ASC Engineered Solution]**
 - c. **[Bray International, Inc.]**
 - d. **[Keckley Company]**
 - e. **[Stockham; a Crane Co. brand]**
 - f. **[Sure Flow Equipment Inc]**
 - g. **[Val-Matic Valve & Manufacturing Corp.]**
 - h. **<Insert manufacturer's name>**
3. Standard: API 594.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **400 psig (2760 kPa)**.
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **300 psig (2070 kPa)**.
6. Body Design: Wafer, spring-loaded plates.
7. Body Material: ASTM A126, gray iron.
8. Seat: Bronze.

GG. Check Valves, Dual-Plate Type - Iron, with Metal Seat, Class 300:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABZ Valve; an ASC Engineered Solution]**
 - b. **[Anvil; an ASC Engineered Solution]**
 - c. **[Bray International, Inc.]**
 - d. **[Keckley Company]**
 - e. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - f. **[Sure Flow Equipment Inc]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. **[ABZ Valve; an ASC Engineered Solution]**
 - b. **[Anvil; an ASC Engineered Solution]**
 - c. **[Bray International, Inc.]**
 - d. **[Keckley Company]**
 - e. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - f. **[Sure Flow Equipment Inc]**
 - g. **<Insert manufacturer's name>**
3. Standard: API 594.
 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **500 psig (3450 kPa)**.
 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **400 psig (2760 kPa)**.
 6. Body Design: Wafer, spring-loaded plates.
 7. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
 8. Seat: Bronze.

HH. Check Valves, Single-Plate Type - Iron, with Resilient Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[GA Industries, Inc]**
 - b. **[Jomar Valve]**
 - c. **[Keckley Company]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[GA Industries, Inc]**
 - b. **[Jomar Valve]**
 - c. **[Keckley Company]**
 - d. **<Insert manufacturer's name>**
3. Standard: API 594.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa)**.
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa)**.
6. Body Design: Wafer, single spring-loaded plate.
7. Body Material: ASTM A126, gray iron.
8. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

II. Check Valves, Dual-Plate Type - Iron, with Resilient Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bray International, Inc.]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[Keckley Company]**
 - d. **[Stockham; a Crane Co. brand]**

- e. **[Sure Flow Equipment Inc]**
- f. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Bray International, Inc.]**
- b. **[Flomatic Valves; Flomatic Corporation]**
- c. **[Keckley Company]**
- d. **[Stockham; a Crane Co. brand]**
- e. **[Sure Flow Equipment Inc]**
- f. **<Insert manufacturer's name>**

- 3. Standard: API 594.
- 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa)**.
- 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa)**.
- 6. Body Design: Wafer, spring-loaded plates.
- 7. Body Material: ASTM A126, gray iron.
- 8. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

JJ. Check Valves, Dual-Plate Type - Iron, with Resilient Seat, Class 150:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. **[Bray International, Inc.]**
- b. **[DeZURIK]**
- c. **[Keckley Company]**
- d. **[Stockham; a Crane Co. brand]**
- e. **[Sure Flow Equipment Inc]**
- f. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Bray International, Inc.]**
- b. **[DeZURIK]**
- c. **[Keckley Company]**
- d. **[Stockham; a Crane Co. brand]**
- e. **[Sure Flow Equipment Inc]**
- f. **<Insert manufacturer's name>**

- 3. Standard: API 594.
- 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **300 psig (2070 kPa)**.
- 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **250 psig (1725 kPa)**.
- 6. Body Design: Wafer, spring-loaded plates.
- 7. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
- 8. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

KK. Check Valves, Single-Plate Type - Iron, with Resilient Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[GA Industries, Inc]**
 - b. **[Jomar Valve]**
 - c. **[Keckley Company]**
 - d. **[Victaulic Company]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[GA Industries, Inc]**
 - b. **[Jomar Valve]**
 - c. **[Keckley Company]**
 - d. **[Victaulic Company]**
 - e. **<Insert manufacturer's name>**
 3. Standard: API 594.
 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **400 psig (2760 kPa)**.
 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **300 psig (2070 kPa)**.
 6. Body Design: Wafer, single spring-loaded plate.
 7. Body Material: ASTM A126, gray iron.
 8. Seat: EPDM or NBR. See Part 3 check valve schedule articles.
- LL. Check Valves, Dual-Plate Type - Iron, with Resilient Seat, Class 250:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Jomar Valve]**
 - b. **[Keckley Company]**
 - c. **[Stockham; a Crane Co. brand]**
 - d. **[Sure Flow Equipment Inc]**
 - e. **[Val-Matic Valve & Manufacturing Corp.]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Jomar Valve]**
 - b. **[Keckley Company]**
 - c. **[Stockham; a Crane Co. brand]**
 - d. **[Sure Flow Equipment Inc]**
 - e. **[Val-Matic Valve & Manufacturing Corp.]**
 - f. **<Insert manufacturer's name>**
 3. Standard: API 594.
 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **400 psig (2760 kPa)**.
 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **300 psig (2070 kPa)**.

6. Body Design: Wafer, spring-loaded plates.
7. Body Material: ASTM A126, gray iron.
8. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

MM. Check Valves, Dual-Plate Type - Iron, with Resilient Seat, Class 300:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Keckley Company]**
 - b. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - c. **[Sure Flow Equipment Inc]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Keckley Company]**
 - b. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - c. **[Sure Flow Equipment Inc]**
 - d. **<Insert manufacturer's name>**
3. Standard: API 594.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **500 psig (3450 kPa)**.
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **400 psig (2760 kPa)**.
6. Body Design: Wafer, spring-loaded plates.
7. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
8. Seat: EPDM or NBR. See Part 3 check valve schedule articles.

NN. Check Valves - CPVC, Union-Type Ball Check:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - e. **[IPEX USA LLC]**
 - f. **[Legend Valve & Fitting, Inc]**
 - g. **[NIBCO INC.]**
 - h. **[Spears Manufacturing Company]**
 - i. **[Thermoplastic Valves, Inc]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**

- b. [Asahi/America]
 - c. [GF Piping Systems: Georg Fischer LLC]
 - d. [Hayward Flow Control; Hayward Industries, Inc.]
 - e. [IPEX USA LLC]
 - f. [Legend Valve & Fitting, Inc]
 - g. [NIBCO INC.]
 - h. [Spears Manufacturing Company]
 - i. [Thermoplastic Valves, Inc]
 - j. <Insert manufacturer's name>
- 3. Pressure Rating and Temperature: **125 psig (860 kPa), 150 psig (1035 kPa)**, or other pressure at **73 deg F (23 deg C)** or other temperature. See Part 3 check valve schedule articles.
 - 4. Body Material: CPVC.
 - 5. Body Design: Union-type ball check.
 - 6. End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket or threaded. See Part 3 check valve schedule articles.
 - 7. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket, socket or threaded, threaded, flanged. See Part 3 check valve schedule articles.
 - 8. Ball: CPVC.
 - 9. Seals: EPDM- or FKM-rubber O-rings.

OO. Check Valves - PVC, Union-Type Ball Check:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [GF Piping Systems: Georg Fischer LLC]
 - d. [Hayward Flow Control; Hayward Industries, Inc.]
 - e. [IPEX USA LLC]
 - f. [Legend Valve & Fitting, Inc]
 - g. [NIBCO INC.]
 - h. [Spears Manufacturing Company]
 - i. [Thermoplastic Valves, Inc]
 - j. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [American Valve, Inc]
 - b. [Asahi/America]
 - c. [GF Piping Systems: Georg Fischer LLC]
 - d. [Hayward Flow Control; Hayward Industries, Inc.]
 - e. [IPEX USA LLC]
 - f. [Legend Valve & Fitting, Inc]
 - g. [NIBCO INC.]
 - h. [Spears Manufacturing Company]
 - i. [Thermoplastic Valves, Inc]
 - j. <Insert manufacturer's name>
- 3. Pressure Rating and Temperature: **125 psig (860 kPa) 150 psig (1035 kPa)**, or other pressure at **73 deg F (23 deg C)** or other temperature. See Part 3 check valve schedule articles.

4. Body Material: PVC.
5. Body Design: Union-type ball check.
6. End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket or threaded. See Part 3 check valve schedule articles.
7. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket, socket or threaded, threaded, flanged. See Part 3 check valve schedule articles.
8. Ball: PVC.
9. Seals: EPDM- or FKM-rubber O-rings.

2.8 GATE VALVES

A. Gate Valves, Threaded or Soldered Ends - Bronze, NRS, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Valve, Inc]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Crane Fluid Systems; Crane Co.]**
 - d. **[FNW; Ferguson Enterprises, Inc.]**
 - e. **[Jenkins Valves; a Crane Co. brand]**
 - f. **[KITZ Corporation]**
 - g. **[Lance Valves]**
 - h. **[Milwaukee Valve Company]**
 - i. **[Powell Valves]**
 - j. **[Red-White Valve Corp.]**
 - k. **[Stockham; a Crane Co. brand]**
 - l. **[WATTS; A Watts Water Technologies Company]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Crane Fluid Systems; Crane Co.]**
 - d. **[FNW; Ferguson Enterprises, Inc.]**
 - e. **[Jenkins Valves; a Crane Co. brand]**
 - f. **[KITZ Corporation]**
 - g. **[Lance Valves]**
 - h. **[Milwaukee Valve Company]**
 - i. **[Powell Valves]**
 - j. **[Red-White Valve Corp.]**
 - k. **[Stockham; a Crane Co. brand]**
 - l. **[WATTS; A Watts Water Technologies Company]**
 - m. **<Insert manufacturer's name>**
3. Standard: MSS SP-80, Type 1.
4. CWP Rating: **200 psig (1380 kPa)**.
5. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
6. Ends: Threaded or soldered. See Part 3 gate valve schedule articles.

7. Stem: Bronze.
8. Disc: Solid wedge; bronze.
9. Packing: Asbestos free.
10. Handwheel: Malleable iron[, bronze, or aluminum].

B. Gate Valves, Threaded or Soldered Ends - Bronze, RS, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[FNW; Ferguson Enterprises, Inc.]**
 - d. **[Hammond Valve]**
 - e. **[Jenkins Valves; a Crane Co. brand]**
 - f. **[KITZ Corporation]**
 - g. **[Milwaukee Valve Company]**
 - h. **[NIBCO INC.]**
 - i. **[Powell Valves]**
 - j. **[Red-White Valve Corp.]**
 - k. **[Stockham; a Crane Co. brand]**
 - l. **[WATTS; A Watts Water Technologies Company]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[FNW; Ferguson Enterprises, Inc.]**
 - d. **[Hammond Valve]**
 - e. **[Jenkins Valves; a Crane Co. brand]**
 - f. **[KITZ Corporation]**
 - g. **[Milwaukee Valve Company]**
 - h. **[NIBCO INC.]**
 - i. **[Powell Valves]**
 - j. **[Red-White Valve Corp.]**
 - k. **[Stockham; a Crane Co. brand]**
 - l. **[WATTS; A Watts Water Technologies Company]**
 - m. **<Insert manufacturer's name>**
3. Standard: MSS SP-80, Type 2.
4. CWP Rating: **200 psig (1380 kPa)**.
5. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
6. Ends: Threaded or soldered. See Part 3 gate valve schedule articles.
7. Stem: Bronze.
8. Disc: Solid wedge; bronze.
9. Packing: Asbestos free.
10. Handwheel: Malleable iron, bronze, or aluminum.

C. Gate Valves, Threaded Ends - Bronze, NRS, Class 150:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [American Valve, Inc]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [Crane Fluid Systems; Crane Co.]
- d. [Jenkins Valves; a Crane Co. brand]
- e. [KITZ Corporation]
- f. [Lance Valves]
- g. [Milwaukee Valve Company]
- h. [Powell Valves]
- i. [Red-White Valve Corp.]
- j. [Stockham; a Crane Co. brand]
- k. [WATTS; A Watts Water Technologies Company]
- l. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [American Valve, Inc]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [Crane Fluid Systems; Crane Co.]
- d. [Jenkins Valves; a Crane Co. brand]
- e. [KITZ Corporation]
- f. [Lance Valves]
- g. [Milwaukee Valve Company]
- h. [Powell Valves]
- i. [Red-White Valve Corp.]
- j. [Stockham; a Crane Co. brand]
- k. [WATTS; A Watts Water Technologies Company]
- l. <Insert manufacturer's name>

- 3. Standard: MSS SP-80, Type 1.
- 4. CWP Rating: **300 psig (2070 kPa)**.
- 5. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
- 6. Ends: Threaded.
- 7. Stem: Bronze.
- 8. Disc: Solid wedge, bronze.
- 9. Packing: Asbestos free.
- 10. Handwheel: Malleable iron[, **bronze, or aluminum**].

D. Gate Valves, Threaded Ends - Bronze, RS, Class 150:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- b. [Crane Fluid Systems; Crane Co.]
- c. [Hammond Valve]
- d. [Jenkins Valves; a Crane Co. brand]
- e. [KITZ Corporation]

- f. **[Milwaukee Valve Company]**
 - g. **[Powell Valves]**
 - h. **[Stockham; a Crane Co. brand]**
 - i. **[WATTS; A Watts Water Technologies Company]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Hammond Valve]**
 - d. **[Jenkins Valves; a Crane Co. brand]**
 - e. **[KITZ Corporation]**
 - f. **[Milwaukee Valve Company]**
 - g. **[Powell Valves]**
 - h. **[Stockham; a Crane Co. brand]**
 - i. **[WATTS; A Watts Water Technologies Company]**
 - j. **<Insert manufacturer's name>**
3. Standard: MSS SP-80, Type 2.
4. CWP Rating: **300 psig (2070 kPa)**.
5. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
6. Ends: Threaded.
7. Stem: Bronze.
8. Disc: Solid wedge, bronze.
9. Packing: Asbestos free.
10. Handwheel: Malleable iron[, **bronze, or aluminum**].
- E. Gate Valves, Press Ends - Bronze:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]**
 - c. **[Hammond Valve]**
 - d. **[Milwaukee Valve Company]**
 - e. **[NIBCO INC.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]**
 - c. **[Hammond Valve]**
 - d. **[Milwaukee Valve Company]**
 - e. **[NIBCO INC.]**
 - f. **<Insert manufacturer's name>**
3. Standard: MSS SP-80.

4. CWP Rating: Minimum **200 psig (1380 kPa)**.
5. Body Material: Bronze with integral seat and union-ring bonnet.
6. Ends: Press.
7. Press Ends Connection Rating: Minimum **200 psig (1380 kPa)**.
8. Stem: Brass or bronze RS or NRS. See Part 3 gate valve schedule articles.
9. Disc: Solid wedge, bronze.
10. Packing: Graphite.
11. Port: Full.
12. Handwheel: Malleable iron, bronze, or aluminum.

F. Gate Valves, Flanged Ends - Iron, NRS, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - c. **[Cooper Valves]**
 - d. **[Crane Fluid Systems; Crane Co.]**
 - e. **[Flomatic Valves; Flomatic Corporation]**
 - f. **[FNW; Ferguson Enterprises, Inc.]**
 - g. **[Jenkins Valves; a Crane Co. brand]**
 - h. **[Jomar Valve]**
 - i. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - j. **[KITZ Corporation]**
 - k. **[Lance Valves]**
 - l. **[Legend Valve & Fitting, Inc]**
 - m. **[Powell Valves]**
 - n. **[Zurn Industries, LLC]**
 - o. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - c. **[Cooper Valves]**
 - d. **[Crane Fluid Systems; Crane Co.]**
 - e. **[Flomatic Valves; Flomatic Corporation]**
 - f. **[FNW; Ferguson Enterprises, Inc.]**
 - g. **[Jenkins Valves; a Crane Co. brand]**
 - h. **[Jomar Valve]**
 - i. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - j. **[KITZ Corporation]**
 - k. **[Lance Valves]**
 - l. **[Legend Valve & Fitting, Inc]**
 - m. **[Powell Valves]**
 - n. **[Zurn Industries, LLC]**
 - o. **<Insert manufacturer's name>**
3. Standard: MSS SP-70, Type I.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa)**.

5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa).**
6. Body Material: ASTM A126, gray iron with bolted bonnet.
7. Ends: Flanged.
8. Trim: Bronze.
9. Disc: Solid wedge.
10. Packing and Gasket: Asbestos free.

G. Gate Valves, Flanged Ends - Iron, OS&Y, Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[FNW; Ferguson Enterprises, Inc.]**
 - d. **[Hammond Valve]**
 - e. **[Jomar Valve]**
 - f. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - g. **[KITZ Corporation]**
 - h. **[Lance Valves]**
 - i. **[Legend Valve & Fitting, Inc]**
 - j. **[Milwaukee Valve Company]**
 - k. **[Powell Valves]**
 - l. **[Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]**
 - m. **[WATTS; A Watts Water Technologies Company]**
 - n. **[Zurn Industries, LLC]**
 - o. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[FNW; Ferguson Enterprises, Inc.]**
 - d. **[Hammond Valve]**
 - e. **[Jomar Valve]**
 - f. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - g. **[KITZ Corporation]**
 - h. **[Lance Valves]**
 - i. **[Legend Valve & Fitting, Inc]**
 - j. **[Milwaukee Valve Company]**
 - k. **[Powell Valves]**
 - l. **[Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]**
 - m. **[WATTS; A Watts Water Technologies Company]**
 - n. **[Zurn Industries, LLC]**
 - o. **<Insert manufacturer's name>**
3. Standard: MSS SP-70, Type I.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa).**
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa).**
6. Body Material: ASTM A126, gray iron with bolted bonnet.

7. Ends: Flanged.
8. Trim: Bronze.
9. Disc: Solid wedge.
10. Packing and Gasket: Asbestos free.

H. Gate Valves, Flanged Ends - Iron, NRS, Class 250:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - c. **[Cooper Valves]**
 - d. **[Crane Fluid Systems; Crane Co.]**
 - e. **[Flomatic Valves; Flomatic Corporation]**
 - f. **[FNW; Ferguson Enterprises, Inc.]**
 - g. **[Jenkins Valves; a Crane Co. brand]**
 - h. **[KITZ Corporation]**
 - i. **[Victaulic Company]**
 - j. **[Zurn Industries, LLC]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - c. **[Cooper Valves]**
 - d. **[Crane Fluid Systems; Crane Co.]**
 - e. **[Flomatic Valves; Flomatic Corporation]**
 - f. **[FNW; Ferguson Enterprises, Inc.]**
 - g. **[Jenkins Valves; a Crane Co. brand]**
 - h. **[KITZ Corporation]**
 - i. **[Victaulic Company]**
 - j. **[Zurn Industries, LLC]**
 - k. **<Insert manufacturer's name>**
3. Standard: MSS SP-70, Type I.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **500 psig (3450 kPa).**
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **300 psig (2070 kPa).**
6. Body Material: ASTM A126, gray iron with bolted bonnet.
7. Ends: Flanged.
8. Trim: Bronze.
9. Disc: Solid wedge.
10. Packing and Gasket: Asbestos free.

I. Gate Valves, Flanged Ends - Iron, OS&Y, Class 250:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Crane Fluid Systems; Crane Co.]
 - c. [FNW; Ferguson Enterprises, Inc.]
 - d. [Hammond Valve]
 - e. [KITZ Corporation]
 - f. [Milwaukee Valve Company]
 - g. [Powell Valves]
 - h. [Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]
 - i. [Victaulic Company]
 - j. [WATTS; A Watts Water Technologies Company]
 - k. [Zurn Industries, LLC]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Crane Fluid Systems; Crane Co.]
 - c. [FNW; Ferguson Enterprises, Inc.]
 - d. [Hammond Valve]
 - e. [KITZ Corporation]
 - f. [Milwaukee Valve Company]
 - g. [Powell Valves]
 - h. [Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America]
 - i. [Victaulic Company]
 - j. [WATTS; A Watts Water Technologies Company]
 - k. [Zurn Industries, LLC]
 - l. <Insert manufacturer's name>
3. Standard: MSS SP-70, Type I.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **500 psig (3450 kPa).**
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **300 psig (2070 kPa).**
6. Body Material: ASTM A126, gray iron with bolted bonnet.
7. Ends: Flanged.
8. Trim: Bronze.
9. Disc: Solid wedge.
10. Packing and Gasket: Asbestos free.

J. Gate Valves - CPVC:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Asahi/America]
 - b. [KITZ Corporation]
 - c. [Spears Manufacturing Company]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Asahi/America]**
 - b. **[KITZ Corporation]**
 - c. **[Spears Manufacturing Company]**
 - d. **<Insert manufacturer's name>**
3. Pressure Rating and Temperature: **125 psig (860 kPa), 150 psig (1035 kPa)**, or other pressure at **73 deg F (23 deg C)** or other temperature. See Part 3 gate valve schedule articles.
4. Body Material: CPVC.
5. Body Design: NRS.
6. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or threaded. See Part 3 gate valve schedule articles.
7. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Socket, socket or threaded, threaded, or flanged. See Part 3 gate valve schedule articles.
8. Gate and Stem: Plastic.
9. Seals: EPDM rubber.
10. Handle: Wheel.

K. Gate Valves - PVC:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Asahi/America]**
 - b. **[KITZ Corporation]**
 - c. **[Spears Manufacturing Company]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Asahi/America]**
 - b. **[KITZ Corporation]**
 - c. **[Spears Manufacturing Company]**
 - d. **<Insert manufacturer's name>**
3. Pressure Rating and Temperature: **125 psig (860 kPa), 150 psig (1035 kPa)**, or other pressure at **73 deg F (23 deg C)** or other temperature. See Part 3 gate valve schedule articles.
4. Body Material: PVC.
5. Body Design: NRS.
6. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or threaded. See Part 3 gate valve schedule articles.
7. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **[Socket][Socket or threaded][Threaded][Flanged]**.
8. Gate and Stem: Plastic.
9. Seals: EPDM rubber.
10. Handle: Wheel.

2.9 PLUG VALVES

- A. Plug Valves, Lubricated Type, Threaded Ends - Class 125:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[American Valve, Inc]**
 - c. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - d. **[DeZURIK]**
 - e. **[Flowserve Corporation]**
 - f. **[Homestead Valve: a division of Olson Technologies, Inc.]**
 - g. **[Nordstrom; a Flowserve Corporation brand]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[American Valve, Inc]**
 - c. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - d. **[DeZURIK]**
 - e. **[Flowserve Corporation]**
 - f. **[Homestead Valve: a division of Olson Technologies, Inc.]**
 - g. **[Nordstrom; a Flowserve Corporation brand]**
 - h. **<Insert manufacturer's name>**
 3. Standard: MSS SP-78, Type I, single gland.
 4. CWP Rating, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **200 psig (1380 kPa)**.
 5. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
 6. Plug: Cast iron or bronze with sealant groove.
- B. Plug Valves, Lubricated Type, Flanged Ends - Class 125:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Crispin Valve]**
 - b. **[DeZURIK]**
 - c. **[Flomatic Valves; Flomatic Corporation]**
 - d. **[Flowserve Corporation]**
 - e. **[GA Industries, Inc]**
 - f. **[Homestead Valve: a division of Olson Technologies, Inc.]**
 - g. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - h. **[National Oilwell Varco]**
 - i. **[NIBCO INC.]**
 - j. **[Nordstrom; a Flowserve Corporation brand]**
 - k. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crispin Valve]**



- b. [DeZURIK]
- c. [Flomatic Valves; Flomatic Corporation]
- d. [Flowserve Corporation]
- e. [GA Industries, Inc]
- f. [Homestead Valve: a division of Olson Technologies, Inc.]
- g. [Kennedy Valve Company; a division of McWane, Inc.]
- h. [National Oilwell Varco]
- i. [NIBCO INC.]
- j. [Nordstrom; a Flowserve Corporation brand]
- k. <Insert manufacturer's name>

- 3. Standard: MSS SP-78, Type I single gland or Type II regular gland. See Part 3 plug valve schedule articles.
- 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa).**
- 5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **150 psig (1035 kPa).**
- 6. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
- 7. Plug: Cast iron or bronze with sealant groove.

C. Plug Valves, Lubricated Type, Threaded Ends - Cylindrical, Class 125:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Flowserve Corporation]
 - b. [Homestead Valve: a division of Olson Technologies, Inc.]
 - c. [National Oilwell Varco]
 - d. [Nordstrom; a Flowserve Corporation brand]
 - e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Flowserve Corporation]
 - b. [Homestead Valve: a division of Olson Technologies, Inc.]
 - c. [National Oilwell Varco]
 - d. [Nordstrom; a Flowserve Corporation brand]
 - e. <Insert manufacturer's name>
- 3. Standard: MSS SP-78, Type IV.
- 4. CWP Rating, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **200 psig (1380 kPa).**
- 5. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
- 6. Plug: Cast iron or bronze with sealant groove.

D. Plug Valves, Lubricated Type, Flanged Ends - Cylindrical, Class 125:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Flomatic Valves; Flomatic Corporation]
 - b. [Flowserve Corporation]

- c. [Homestead Valve: a division of Olson Technologies, Inc.]
 - d. [National Oilwell Varco]
 - e. [Nordstrom; a Flowserve Corporation brand]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Flomatic Valves; Flomatic Corporation]
 - b. [Flowserve Corporation]
 - c. [Homestead Valve: a division of Olson Technologies, Inc.]
 - d. [National Oilwell Varco]
 - e. [Nordstrom; a Flowserve Corporation brand]
 - f. <Insert manufacturer's name>
 3. Standard: MSS SP-78, Type IV.
 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **200 psig (1380 kPa)**.
 5. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
 6. Plug: Cast iron or bronze with sealant groove.
- E. Plug Valves, Lubricated Type, Threaded Ends - Class 250:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [DeZURIK]
 - b. [Homestead Valve: a division of Olson Technologies, Inc.]
 - c. [National Oilwell Varco]
 - d. [Nordstrom; a Flowserve Corporation brand]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [DeZURIK]
 - b. [Homestead Valve: a division of Olson Technologies, Inc.]
 - c. [National Oilwell Varco]
 - d. [Nordstrom; a Flowserve Corporation brand]
 - e. <Insert manufacturer's name>
 3. Standard: MSS SP-78, Type I single gland or Type II regular gland. See Part 3 plug valve schedule articles.
 4. CWP Rating, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **400 psig (2760 kPa)**.
 5. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
 6. Plug: Cast iron or bronze with sealant groove.
- F. Plug Valves, Lubricated Type, Flanged Ends - Class 250:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Crispin Valve]
- b. [DeZURIK]
- c. [Flowserve Corporation]
- d. [Homestead Valve: a division of Olson Technologies, Inc.]
- e. [Kennedy Valve Company; a division of McWane, Inc.]
- f. [National Oilwell Varco]
- g. [Nordstrom; a Flowserve Corporation brand]
- h. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Crispin Valve]
- b. [DeZURIK]
- c. [Flowserve Corporation]
- d. [Homestead Valve: a division of Olson Technologies, Inc.]
- e. [Kennedy Valve Company; a division of McWane, Inc.]
- f. [National Oilwell Varco]
- g. [Nordstrom; a Flowserve Corporation brand]
- h. <Insert manufacturer's name>

3. Standard: MSS SP-78, Type I single gland or Type II regular gland. See Part 3 plug valve schedule articles.
4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **400 psig (2760 kPa)**.
5. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): **300 psig (2070 kPa)**.
6. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
7. Plug: Cast iron or bronze with sealant groove.

G. Plug Valves, Lubricated Type, Threaded Ends - Cylindrical, Class 250:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Flowserve Corporation]
- b. [National Oilwell Varco]
- c. [Nordstrom; a Flowserve Corporation brand]
- d. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Flowserve Corporation]
- b. [National Oilwell Varco]
- c. [Nordstrom; a Flowserve Corporation brand]
- d. <Insert manufacturer's name>

3. Standard: MSS SP-78, Type IV.
4. CWP Rating, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **400 psig (2760 kPa)**.
5. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
6. Plug: Cast iron or bronze with sealant groove.

- H. Plug Valves, Lubricated Type, Flanged Ends - Cylindrical, Class 250:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Flowserve Corporation]**
 - b. **[National Oilwell Varco]**
 - c. **[Nordstrom; a Flowserve Corporation brand]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Flowserve Corporation]**
 - b. **[National Oilwell Varco]**
 - c. **[Nordstrom; a Flowserve Corporation brand]**
 - d. **<Insert manufacturer's name>**
 3. Standard: MSS SP-78, Type IV.
 4. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **400 psig (2760 kPa)**.
 5. Body Material: ASTM A48/A48M or ASTM A126, Grade 40 cast iron with lubrication-sealing system.
 6. Plug: Cast iron or bronze with sealant groove.
- I. Plug Valves, Eccentric Type, Flanged Ends - with Resilient Seat, 175 CWP.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Clow Valve Company; a subsidiary of McWane, Inc.
 - b. DeZURIK.
 - c. Flowserve Corporation.
 - d. GA Industries, Inc.
 - e. Homestead Valve: a division of Olson Technologies, Inc.
 - f. Kennedy Valve Company; a division of McWane, Inc.
 - g. Milliken Valve Company; a Mueller brand.
 - h. National Oilwell Varco.
 - i. Nordstrom; a Flowserve Corporation brand.
 - j. Val-Matic Valve & Manufacturing Corp.
 - k. **<Insert manufacturer's name>**.
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 3. Standard: MSS SP-108.
 4. CWP Rating: **175 psig (1200 kPa)** minimum.
 5. Body and Plug: ASTM A48/A48M, gray iron; ASTM A126, gray iron; or ASTM A536, ductile iron.
 6. Bearings: Oil-impregnated bronze or stainless steel.
 7. Ends: Flanged.
 8. Stem-Seal Packing: Asbestos free.
 9. Plug, Resilient-Seat Material: Suitable for potable-water service unless otherwise indicated.



2.10 CHAINWHEELS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 2. **[Babbitt Steam Specialty Co]**
 3. **[Roto Hammer Industries; Rotork]**
 4. **[Trumbull Industries]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 2. **[Babbitt Steam Specialty Co]**
 3. **[Roto Hammer Industries; Rotork]**
 4. **[Trumbull Industries]**
 5. **<Insert manufacturer's name>**
- C. Description: Valve actuation assembly with sprocket rim, chain guides, chain[, **and attachment brackets for mounting chainwheels directly to handwheels]**.
1. Sprocket Rim with Chain Guides: **[Ductile iron][Ductile or cast iron][Cast iron][Aluminum][Bronze]**, of type and size required for valve. **[Include zinc or epoxy coating.]**
 2. Chain: **[Hot-dip, galvanized steel][Brass][Stainless steel]**, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Examine press fittings to verify they have been properly pressed.
- F. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance,

and equipment removal without system shutdown.

- B. Provide support of piping adjacent to valves such that no force is imposed upon valves.
- C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.
- D. For valves in horizontal piping, install valves with stem at or above center of pipe.
- E. Install valves in position that does not project into aisles or block access to other equipment.
- F. Install valves in position to allow full stem and actuator or manual operator movement.
- G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.
- H. Chainwheels: Install chainwheels on manual operators for **[globe][butterfly][gate][and][plug]** valves **[NPS 4 (DN 100)]<Insert pipe size>** and larger and more than **[96 inches (2400 mm)]<Insert dimension>** above floor. Extend chains to **[60 inches (1520 mm)]<Insert dimension>** above finished floor.
- I. Install check valves for proper direction of flow and as follows:
 - 1. Check Valves: **[Center-guided type][and][plate type]**, in horizontal or vertical position, between flanges.
 - 2. Check Valves, Swing Type: In horizontal position with hinge pin level.
 - 3. Check Valves, Lift Type: With stem upright and plumb.
- J. Valve Tags: Comply with requirements for valve tags and schedules in Section 230553 "Identification for HVAC Piping and Equipment."
- K. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve of manufacturer's written recommended maximum.

3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
7. For Grooved-End Copper Tubing, except Steam and Steam Condensate Piping: Valve ends may be grooved.
8. For Grooved-End Steel Piping, except Steam and Steam Condensate Piping: Valve ends may be grooved.
9. Wafer-Type Valves: Flanged connections.

3.5 CHILLED-WATER ANGLE OR GLOBE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Angle valves, threaded ends - bronze, Class 125.
2. Angle valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.
3. Globe valves, threaded or soldered ends - bronze, Class 125; **[threaded][soldered]** ends.
4. Globe valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Globe valves, flanged ends - iron, Class 125.
2. Globe valves, flanged ends - iron, Class 250.

3.6 CONDENSER-WATER ANGLE OR GLOBE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Angle valves, threaded ends - bronze, Class 125.
2. Angle valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.
3. Globe valves, threaded or soldered ends - bronze, Class 125; **[threaded][soldered]** ends.
4. Globe valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Globe valves, flanged ends - iron, Class 125.
2. Globe valves, flanged ends - iron, Class 250.

3.7 HEATING-WATER ANGLE OR GLOBE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Angle valves, threaded ends - bronze, Class 125.
2. Angle valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.
3. Globe valves, threaded or soldered ends - bronze, Class 125; **[threaded][soldered]** ends.
4. Globe valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Globe valves, flanged ends - iron, Class 125.
2. Globe valves, flanged ends - iron, Class 250.

3.8 LOW-PRESSURE STEAM ANGLE OR GLOBE VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS 2 (DN 50) and Smaller:

1. Angle valves, threaded ends - bronze, Class 125.
2. Angle valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.
3. Globe valves, threaded or soldered ends - bronze, Class 125; threaded ends.
4. Globe valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Globe valves, flanged ends - iron, Class 125.
2. Globe valves, flanged ends - iron, Class 250.

3.9 HIGH-PRESSURE STEAM ANGLE OR GLOBE VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS (DN 50) and Smaller:

1. Angle valves, threaded ends - bronze, Class 125.
2. Angle valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.
3. Globe valves, threaded or soldered ends - bronze, Class 125; threaded ends.
4. Globe valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Globe valves, flanged ends - iron, Class 125.
2. Globe valves, flanged ends - iron, Class 250.

3.10 STEAM-CONDENSATE ANGLE OR GLOBE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Angle valves, threaded ends - bronze, Class 125.
2. Angle valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.
3. Globe valves, threaded or soldered ends - bronze, Class 125; threaded ends.
4. Globe valves, threaded ends - bronze, Class 150; **[PTFE][stainless steel]** disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Globe valves, flanged ends - iron, Class 125.
2. Globe valves, flanged ends - iron, Class 250.

3.11 CHILLED-WATER BALL VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Ball valves, threaded ends - brass, one piece.
2. Ball valves, threaded or soldered ends - brass, two piece with full port and brass trim; **[threaded][soldered]** ends.
3. Ball valves, press ends - brass, two piece with full port and brass trim.
4. Ball valves, threaded or soldered ends - brass, two piece with full port and stainless steel trim; **[threaded][soldered]** ends.

5. Ball valves, press ends - brass, two piece with full port and stainless steel trim.
6. Ball valves, threaded or soldered ends - brass, two piece with regular port and brass trim; **[threaded][soldered]** ends.
7. Ball valves, threaded or soldered ends - brass, two piece with regular port and stainless steel trim; **[threaded][soldered]** ends.
8. Ball valves, threaded or soldered ends - brass, three piece with full port and brass trim; **[threaded][soldered]** ends.
9. Ball valves, threaded or soldered ends - brass, three piece with full port and stainless steel trim; **[threaded][soldered]** ends.
10. Ball valves, threaded ends - bronze, one piece with bronze trim.
11. Ball valves, threaded ends - bronze, one piece with stainless steel trim.
12. Ball valves, threaded or soldered ends - bronze, two piece with full port and bronze or brass trim; **[threaded][soldered]** ends.
13. Ball valves, press ends - bronze, two piece with full port and bronze or brass trim.
14. Ball valves, threaded or soldered ends - bronze, two piece with full port and stainless steel trim; **[threaded][soldered]** ends.
15. Ball valves, threaded ends - bronze, two piece with regular port and bronze or brass trim.
16. Ball valves, threaded ends - bronze, two piece with regular port and stainless steel trim.
17. Ball valves, threaded ends - bronze, three piece with full port and bronze or brass trim.
18. Ball valves, threaded ends - bronze, three piece with full port and stainless steel trim.
19. Ball valves, threaded or soldered ends - bronze, three piece with regular port and bronze or brass trim; **[threaded][soldered]** ends.
20. Ball valves, threaded or soldered ends - bronze, three piece with regular port and stainless steel trim; **[threaded][soldered]** ends.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 150.
2. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.
3. Ball valves, flanged ends - iron, Class 125.

3.12 COOLING-COIL CONDENSATE BALL VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Ball valves, threaded or soldered ends - brass, two piece with full port and brass trim; **[threaded][soldered]** ends.
2. Ball valves, press ends - brass, two piece with full port and brass trim.
3. Ball valves, threaded or soldered ends - brass, two piece with regular port and brass trim; **[threaded][soldered]** ends.
4. Ball valves, threaded or soldered ends - bronze, two piece with full port and bronze or brass trim; **[threaded][soldered]** ends.
5. Ball valves, press ends - bronze, two piece with full port and bronze or brass trim.
6. Ball valves, threaded ends - bronze, two piece with regular port and bronze or brass trim.

B. For CPVC Pipe:

1. CPVC Union-Type Ball Valve: **[NPS 2 (DN 50) and smaller][NPS 4 (DN 100) and smaller][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure>** at **[73 deg F (23 deg C)]<Insert temperature>**.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: **[Socket][or][threaded]**.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **[Socket][Socket or threaded][Threaded][Flanged]**.

C. For PVC Pipe:

1. PVC Union-Type Ball Valve: **[NPS 2 (DN 50) and smaller][NPS 4 (DN 100) and smaller][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.**
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: **[Socket][or][threaded].**
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **[Socket][Socket or threaded][Threaded][Flanged].**

3.13 CONDENSER-WATER BALL VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Ball valves, threaded ends - brass, one piece.
2. Ball valves, threaded or soldered ends - brass, two piece with full port and brass trim; **[threaded][soldered]** ends.
3. Ball valves, press ends - brass, two piece with full port and brass trim.
4. Ball valves, threaded or soldered ends - brass, two piece with full port and stainless steel trim; **[threaded][soldered]** ends.
5. Ball valves, press ends - brass, two piece with full port and stainless steel trim.
6. Ball valves, threaded or soldered ends - brass, two piece with regular port and brass trim; **[threaded][soldered]** ends.
7. Ball valves, threaded or soldered ends - brass, two piece with regular port and stainless steel trim; **[threaded][soldered]** ends.
8. Ball valves, threaded or soldered ends - brass, three piece with full port and brass trim; **[threaded][soldered]** ends.
9. Ball valves, threaded or soldered ends - brass, three piece with full port and stainless steel trim; **[threaded][soldered]** ends.
10. Ball valves, threaded ends - bronze, one piece with bronze trim.
11. Ball valves, threaded ends - bronze, one piece with stainless steel trim.
12. Ball valves, threaded or soldered ends - bronze, two piece with full port and bronze or brass trim; **[threaded][soldered]** ends.
13. Ball valves, press ends - bronze, two piece with full port and bronze or brass trim.
14. Ball valves, threaded or soldered ends - bronze, two piece with full port and stainless steel trim; **[threaded][soldered]** ends.
15. Ball valves, threaded ends - bronze, two piece with regular port and bronze or brass trim.
16. Ball valves, threaded ends - bronze, two piece with regular port and stainless steel trim.
17. Ball valves, threaded ends - bronze, three piece with full port and bronze or brass trim.
18. Ball valves, threaded ends - bronze, three piece with full port and stainless steel trim.
19. Ball valves, threaded or soldered ends - bronze, three piece with regular port and bronze or brass trim; **[threaded][soldered]** ends.
20. Ball valves, threaded or soldered ends - bronze, three piece with regular port and stainless steel trim; **[threaded][soldered]** ends.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 150.
2. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.
3. Ball valves, flanged ends - iron, Class 125.

C. For CPVC Pipe:

1. CPVC Union-Type Ball Valve: **[NPS 2 (DN 50) and smaller][NPS 4 (DN 100) and smaller][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure> at [73 deg F**

(23 deg C)]<Insert temperature>.

- a. End Connections for Valves NPS 2 (DN 50) and Smaller: **[Socket][or][threaded]**.
- b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **[Socket][Socket or threaded][Threaded][Flanged]**.

D. For PVC Pipe:

1. PVC Union-Type Ball Valve: **[NPS 2 (DN 50) and smaller][NPS 4 (DN 100) and smaller][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.**
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: **[Socket][or][threaded]**.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **[Socket][Socket or threaded][Threaded][Flanged]**.

3.14 HEATING-WATER BALL VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Ball valves, threaded ends - brass, one piece.
2. Ball valves, threaded or soldered ends - brass, two piece with full port and brass trim; **[threaded][soldered]** ends.
3. Ball valves, press ends - brass, two piece with full port and brass trim.
4. Ball valves, threaded or soldered ends - brass, two piece with full port and stainless steel trim; **[threaded][soldered]** ends.
5. Ball valves, press ends - brass, two piece with full port and stainless steel trim.
6. Ball valves, threaded or soldered ends - brass, two piece with regular port and brass trim; **[threaded][soldered]** ends.
7. Ball valves, threaded or soldered ends - brass, two piece with regular port and stainless steel trim; **[threaded][soldered]** ends.
8. Ball valves, threaded or soldered ends - brass, three piece with full port and brass trim; **[threaded][soldered]** ends.
9. Ball valves, threaded or soldered ends - brass, three piece with full port and stainless steel trim; **[threaded][soldered]** ends.
10. Ball valves, threaded ends - bronze, one piece with bronze trim.
11. Ball valves, threaded ends - bronze, one piece with stainless steel trim.
12. Ball valves, threaded or soldered ends - bronze, two piece with full port and bronze or brass trim; **[threaded][soldered]** ends.
13. Ball valves, press ends - bronze, two piece with full port and bronze or brass trim.
14. Ball valves, threaded or soldered ends - bronze, two piece with full port and stainless steel trim; **[threaded][soldered]** ends.
15. Ball valves, threaded ends - bronze, two piece with regular port and bronze or brass trim.
16. Ball valves, threaded ends - bronze, two piece with regular port and stainless steel trim.
17. Ball valves, threaded ends - bronze, three piece with full port and bronze or brass trim.
18. Ball valves, threaded ends - bronze, three piece with full port and stainless steel trim.
19. Ball valves, threaded or soldered ends - bronze, three piece with regular port and bronze or brass trim; **[threaded][soldered]** ends.
20. Ball valves, threaded or soldered ends - bronze, three piece with regular port and stainless steel trim; **[threaded][soldered]** ends.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 150.

2. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.
3. Ball valves, flanged ends - iron, Class 125.

3.15 LOW-PRESSURE STEAM BALL VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS (DN 50) and Smaller:

1. Ball valves, threaded ends - brass, two piece with full port and brass trim.
2. Ball valves, threaded - brass, two piece with full port and stainless steel trim.
3. Ball valves, threaded - brass, two piece with regular port and brass trim.
4. Ball valves, threaded ends - brass, two piece with regular port and stainless steel trim.
5. Ball valves, threaded ends - brass, three piece with full port and brass trim.
6. Ball valves, threaded ends - brass, three piece with full port and stainless steel trim.
7. Ball valves, threaded ends - bronze, two piece with full port and bronze or brass trim.
8. Ball valves, threaded ends - bronze, two piece with full port and stainless steel trim.
9. Ball valves, threaded ends - bronze, two piece with regular port and bronze or brass trim.
10. Ball valves, threaded ends - bronze, two piece with regular port and stainless steel trim.
11. Ball valves, threaded ends - bronze, three piece with full port and bronze or brass trim.
12. Ball valves, threaded ends - bronze, three piece with full port and stainless steel trim.
13. Ball valves, threaded ends - bronze, three piece with regular port and bronze or brass trim.
14. Ball valves, threaded ends - bronze, three piece with regular port and stainless steel trim.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 150.
2. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.
3. Ball valves, flanged ends - iron, Class 125.

3.16 LOW-PRESSURE CLEAN STEAM BALL VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

- A. Pipe NPS 2 (DN 50) and Smaller:** Ball valves, threaded ends - stainless steel, two piece with full port.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:** Ball valves, flanged ends - stainless steel, two piece with full port.

3.17 HIGH-PRESSURE STEAM BALL VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2 (DN 50) and Smaller:

1. Ball valves, threaded ends - brass, two piece with full port and brass trim.
2. Ball valves, threaded ends - brass, two piece with full port and stainless steel trim.
3. Ball valves, threaded ends - brass, two piece with regular port and brass trim.
4. Ball valves, threaded ends - brass, two piece with regular port and stainless steel trim.
5. Ball valves, threaded ends - brass, three piece with full port and brass trim.
6. Ball valves, threaded ends - brass, three piece with full port and stainless steel trim.
7. Ball valves, threaded ends - bronze, two piece with full port and bronze or brass trim.
8. Ball valves, threaded ends - bronze, two piece with full port and stainless steel trim.
9. Ball valves, threaded ends - bronze, two piece with regular port and bronze or brass trim.
10. Ball valves, threaded ends - bronze, two piece with regular port and stainless steel trim.
11. Ball valves, threaded ends - bronze, three piece with full port and bronze or brass trim.
12. Ball valves, threaded ends - bronze, three piece with full port and stainless steel trim.
13. Ball valves, threaded ends - bronze, three piece with regular port and bronze or brass trim.
14. Ball valves, threaded ends - bronze, three piece with regular port and stainless steel trim.

- B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 150.
 2. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.
 3. Ball valves, flanged ends - iron, Class 125.
- 3.18 HIGH-PRESSURE CLEAN STEAM BALL VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)
- A. Pipe NPS 2 (DN 50) and Smaller: Ball valves, threaded ends - stainless steel, two piece with full port.
- B. Pipe NPS 2-1/2 (DN 65) and Larger: Ball valves, flanged ends - stainless steel, two piece with full port.
- 3.19 STEAM-CONDENSATE BALL VALVE SCHEDULE
- A. Pipe NPS 2 (DN 50) and Smaller:
1. Ball valves, threaded ends - brass, two piece with full port and brass trim.
 2. Ball valves, threaded ends - brass, two piece with full port and stainless steel trim.
 3. Ball valves, threaded ends - brass, two piece with regular port and brass trim.
 4. Ball valves, threaded ends - brass, two piece with regular port and stainless steel trim.
 5. Ball valves, threaded ends - brass, three piece with full port and brass trim.
 6. Ball valves, threaded ends - brass, three piece with full port and stainless steel trim.
 7. Ball valves, threaded ends - bronze, two piece with full port and bronze or brass trim.
 8. Ball valves, threaded ends - bronze, two piece with full port and stainless steel trim.
 9. Ball valves, threaded ends - bronze, two piece with regular port and bronze or brass trim.
 10. Ball valves, threaded ends - bronze, two piece with regular port and stainless steel trim.
 11. Ball valves, threaded ends - bronze, three piece with full port and bronze or brass trim.
 12. Ball valves, threaded ends - bronze, three piece with full port and stainless steel trim.
 13. Ball valves, threaded ends - bronze, three piece with regular port and bronze or brass trim.
 14. Ball valves, threaded ends - bronze, three piece with regular port and stainless steel trim.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 150.
 2. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.
 3. Ball valves, flanged ends - iron, Class 125.
- 3.20 CLEAN STEAM-CONDENSATE BALL VALVE SCHEDULE
- A. Pipe NPS 2 (DN 50) and Smaller: Ball valves, threaded ends - stainless steel, two piece with full port.
- B. Pipe NPS 2-1/2 (DN 65) and Larger: Ball valves, flanged ends - stainless steel, two piece with full port.
- 3.21 CHILLED-WATER BUTTERFLY VALVE SCHEDULE
- A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Butterfly valves, single flange (lug type) - iron, with aluminum-bronze disc; **[150][200]** CWP, **[EPDM][NBR]** seat.
 2. Butterfly valves, single flange (lug type) - iron, with ductile-iron disc; **[150][200]** CWP,

- [EPDM][NBR] seat.
- 3. Butterfly valves, single flange (lug type) - iron, with stainless steel disc; [150][200] CWP, [EPDM][NBR] seat.
- 4. Butterfly valves, flangeless (wafer type) - iron, with aluminum-bronze disc; [150][200] CWP, [EPDM][NBR] seat.
- 5. Butterfly valves, flangeless (wafer type) - iron, with ductile-iron disc; [150][200] CWP, [EPDM][NBR] seat.
- 6. Butterfly valves, flangeless (wafer type) - iron, with stainless steel disc; [150][200] CWP, [EPDM][NBR] seat.
- 7. Butterfly valves, grooved end - ductile iron, 175 CWP.
- 8. Butterfly valves, grooved end - ductile iron, 300 CWP.
- 9. Butterfly valves, single flange (lug type) - high performance, Class 150; [carbon steel][stainless steel] body.
- 10. Butterfly valves, single flange (lug type) - high performance, Class 300; [carbon steel][stainless steel] body.

3.22 CONDENSER-WATER BUTTERFLY VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

- 1. Butterfly valves, single flange (lug type) - iron, with aluminum-bronze disc; [150][200] CWP, [EPDM][NBR] seat.
- 2. Butterfly valves, single flange (lug type) - iron, with ductile-iron disc; [150][200] CWP, [EPDM][NBR] seat.
- 3. Butterfly valves, single flange (lug type) - iron, with stainless steel disc; [150][200] CWP, [EPDM][NBR] seat.
- 4. Butterfly valves, flangeless (wafer type) - iron, with aluminum-bronze disc; [150][200] CWP, [EPDM][NBR] seat.
- 5. Butterfly valves, flangeless (wafer type) - iron, with ductile-iron disc: [150][200] CWP, [EPDM][NBR] seat.
- 6. Butterfly valves, flangeless (wafer type) - iron, with stainless steel disc; [150][200] CWP, [EPDM][NBR] seat.
- 7. Butterfly valves, grooved end - ductile iron, 175 CWP.
- 8. Butterfly valves, grooved end - ductile iron, 300 CWP.
- 9. Butterfly valves, single flange (lug type) - high performance, Class 150; [carbon steel][stainless steel] body.
- 10. Butterfly valves, single flange (lug type) - high performance, Class 300; [carbon steel][stainless steel] body.

3.23 HEATING-WATER BUTTERFLY VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

- 1. Butterfly valves, single flange (lug type) - iron, with aluminum-bronze disc; [150][200] CWP, [EPDM][NBR] seat.
- 2. Butterfly valves, single flange (lug type) - iron, with ductile-iron disc; [150][200] CWP, [EPDM][NBR] seat.
- 3. Butterfly valves, single flange (lug type) - iron, with stainless steel disc; [150][200] CWP, [EPDM][NBR] seat.
- 4. Butterfly valves, flangeless (wafer type) - iron, with aluminum-bronze disc; [150][200] CWP, [EPDM][NBR] seat.
- 5. Butterfly valves, flangeless (wafer type) - iron, with ductile-iron disc: [150][200] CWP, [EPDM][NBR] seat.
- 6. Butterfly valves, flangeless (wafer type) - iron, with stainless steel disc; [150][200] CWP,

[EPDM][NBR] seat.

7. Butterfly valves, grooved end - ductile iron, 175 CWP.
8. Butterfly valves, grooved end - ductile iron, 300 CWP.
9. Butterfly valves, single flange (lug type) - high performance, Class 150; [carbon steel][stainless steel] body.
10. Butterfly valves, single flange (lug type) - high performance, Class 300; [carbon steel][stainless steel] body.

3.24 LOW-PRESSURE STEAM BUTTERFLY VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Butterfly valves, single flange (lug type) - high performance, Class 150; [carbon steel][stainless steel] body.
2. Butterfly valves, single flange (lug type) - high performance, Class 300; [carbon steel][stainless steel] body.

3.25 LOW-PRESSURE CLEAN STEAM BUTTERFLY VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Butterfly valves, single flange (lug type) - high performance, Class 150; stainless steel body.
2. Butterfly valves, single flange (lug type) - high performance, Class 300; stainless steel body.

3.26 HIGH-PRESSURE STEAM BUTTERFLY VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Butterfly valves, single flange (lug type) - high-performance, Class 150 [carbon steel][stainless steel] body.
2. Butterfly valves, single flange (lug type) - high-performance, Class 300 [carbon steel][stainless steel] body.

3.27 HIGH-PRESSURE CLEAN STEAM BUTTERFLY VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Butterfly valves, single flange (lug type) - high performance, Class 150; stainless steel body.
2. Butterfly valves, single flange (lug type) - high performance, Class 300; stainless steel body.

3.28 STEAM-CONDENSATE BUTTERFLY VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Butterfly valves, single flange (lug type) - high performance, Class 150; [carbon steel][stainless steel] body.
2. Butterfly valves, single flange (lug type) - high performance, Class 300; [carbon steel][stainless steel] body.

3.29 CLEAN-STEAM-CONDENSATE BUTTERFLY VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Butterfly valves, single flange (lug type) - high performance, Class 150; stainless steel body.
2. Butterfly valves, single flange (lug type) - high performance, Class 300; stainless steel body.

3.30 CHILLED-WATER CHECK VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Check valves, lift type, threaded ends - bronze, with bronze disc, Class 125.
2. Check valves, lift type, threaded ends - bronze, with nonmetallic disc, Class 125.
3. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
4. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
5. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
6. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.
7. Check valves, swing type, press ends - bronze.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
4. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
5. Check valves, center guided - iron, globe, with metal seat, Class 125.
6. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
7. Check valves, center guided - iron, globe, with metal seat, Class 150.
8. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
9. Check valves, center guided - iron, globe, with metal seat, Class 250.
10. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
11. Check valves, center guided - iron, globe, with metal seat, Class 300.
12. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; [EPDM][NBR].
13. Check valves, center guided - iron, globe, with resilient seat, Class 125; [EPDM][NBR].
14. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; [EPDM][NBR].
15. Check valves, center guided - iron, globe, with resilient seat, Class 150; [EPDM][NBR].
16. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; [EPDM][NBR].
17. Check valves, center guided - iron, globe, with resilient seat, Class 250; [EPDM][NBR].
18. Check valves, center guided - iron, compact wafer, with resilient seat, Class 300; [EPDM][NBR].
19. Check valves, center guided - iron, globe, with resilient seat, Class 300; [EPDM][NBR].
20. Check valves, dual-plate type - iron, with metal seat, Class 125.
21. Check valves, dual-plate type - iron, with metal seat, Class 150.
22. Check valves, dual-plate type - iron, with metal seat, Class 250.
23. Check valves, dual-plate type - iron, with metal seat, Class 300.
24. Check valves, single-plate type - iron, with resilient seat, Class 125; [EPDM][NBR] seat.
25. Check valves, dual-plate type - iron, with resilient seat, Class 125; [EPDM][NBR] seat.
26. Check valves, dual-plate type - iron, with resilient seat, Class 150; [EPDM][NBR] seat.
27. Check valves, single-plate type - iron, with resilient seat, Class 250; [EPDM][NBR] seat.
28. Check valves, dual-plate type - iron, with resilient seat, Class 250; [EPDM][NBR] seat.
29. Check valves, dual-plate type - iron, with resilient seat, Class 300; [EPDM][NBR] seat.

C. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):

1. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
2. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

- D. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):
1. Check valves, swing type, grooved ends - iron, 300 CWP.
- E. For CPVC Pipe:
1. CPVC Union-Type Ball Check Valve: **[NPS 2 (DN 50) and smaller][NPS 4 (DN 100) and smaller][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.**
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: **[Socket][or][threaded].**
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and Larger: **[Socket][Socket or threaded][Threaded][Flanged].**
- F. For PVC Pipe:
1. PVC Union-Type Ball Check Valve: **[NPS 2 (DN 50) and smaller][NPS 4 (DN 100)][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.**
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: **[Socket][or][threaded].**
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **[Socket][Socket or threaded][Threaded][Flanged].**

3.31 CONDENSER-WATER CHECK VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
1. Check valves, lift type, threaded ends - bronze, with bronze disc, Class 125.
 2. Check valves, lift type, threaded ends - bronze, with nonmetallic disc, Class 125.
 3. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 4. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
 5. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
 6. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.
 7. Check valves, swing type, press ends - bronze.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
 2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
 3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
 4. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
 5. Check valves, center guided - iron, globe, with metal seat, Class 125.
 6. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
 7. Check valves, center guided - iron, globe, with metal seat, Class 150.
 8. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
 9. Check valves, center guided - iron, globe, with metal seat, Class 250.
 10. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
 11. Check valves, center guided - iron, globe, with metal seat, Class 300.
 12. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; **[EPDM][NBR].**
 13. Check valves, center guided - iron, globe, with resilient seat, Class 125; **[EPDM][NBR].**
 14. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; **[EPDM][NBR].**
 15. Check valves, center guided - iron, globe, with resilient seat, Class 150; **[EPDM][NBR].**
 16. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; **[EPDM][NBR].**

17. Check valves, center guided - iron, globe, with resilient seat, Class 250; [EPDM][NBR].
18. Check valves, center guided - iron, compact water, with resilient seat, Class 300; [EPDM][NBR].
19. Check valves, center guided - iron, globe, with resilient seat, Class 300; [EPDM][NBR].
20. Check valves, dual-plate type - iron, with metal seat, Class 125.
21. Check valves, dual-plate type - iron, with metal seat, Class 150.
22. Check valves, dual-plate type - iron, with metal seat, Class 250.
23. Check valves, dual-plate type - iron, with metal seat, Class 300.
24. Check valves, single-plate type - iron, with resilient seat, Class 125; [EPDM][NBR] seat.
25. Check valves, dual-plate type - iron, with resilient seat, Class 125; [EPDM][NBR] seat.
26. Check valves, dual-plate type - iron, with resilient seat, Class 150; [EPDM][NBR] seat.
27. Check valves, single-plate type - iron, with resilient seat, Class 250; [EPDM][NBR] seat.
28. Check valves, dual-plate type - iron, with resilient seat, Class 250; [EPDM][NBR] seat.
29. Check valves, dual-plate type - iron, with resilient seat, Class 300; [EPDM][NBR] seat.

C. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):

1. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
2. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

D. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):

1. Check valves, swing type, grooved ends - iron, 300 CWP.

E. For CPVC Pipe:

1. CPVC Union-Type Ball Check Valve: [NPS 2 (DN 50) and smaller][NPS 4 (DN 100) and smaller][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: [Socket][or][threaded].
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and Larger: [Socket][Socket or threaded][Threaded][Flanged].

F. For PVC Pipe:

1. PVC Union-Type Ball Check Valve: [NPS 2 (DN 50) and smaller][NPS 4 (DN 100)][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: [Socket][or][threaded].
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): [Socket][Socket or threaded][Threaded][Flanged].

3.32 HEATING-WATER CHECK VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Check valves, lift type, threaded ends - bronze, with bronze disc, Class 125.
2. Check valves, lift type, threaded ends - bronze, with nonmetallic disc, Class 125.
3. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
4. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
5. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
6. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.
7. Check valves, swing type, press ends - bronze.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
4. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
5. Check valves, center guided - iron, globe, with metal seat, Class 125.
6. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
7. Check valves, center guided - iron, globe, with metal seat, Class 150.
8. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
9. Check valves, center guided - iron, globe, with metal seat, Class 250.
10. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
11. Check valves, center guided - iron, globe, with metal seat, Class 300.
12. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; [EPDM][NBR].
13. Check valves, center guided - iron, globe, with resilient seat, Class 125; [EPDM][NBR].
14. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; [EPDM][NBR].
15. Check valves, center guided - iron, globe, with resilient seat, Class 150; [EPDM][NBR].
16. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; [EPDM][NBR].
17. Check valves, center guided - iron, globe, with resilient seat, Class 250; [EPDM][NBR].
18. Check valves, center guided - iron, compact wafer, with resilient seat, Class 300; [EPDM][NBR].
19. Check valves, center guided - iron, globe, with resilient seat, Class 300; [EPDM][NBR].
20. Check valves, dual-plate type - iron, with metal seat, Class 125.
21. Check valves, dual-plate type - iron, with metal seat, Class 150.
22. Check valves, dual-plate type - iron, with metal seat, Class 250.
23. Check valves, dual-plate type - iron, with metal seat, Class 300.
24. Check valves, single-plate type - iron, with resilient seat, Class 125; [EPDM][NBR] seat.
25. Check valves, dual-plate type - iron, with resilient seat, Class 125; [EPDM][NBR] seat.
26. Check valves, dual-plate type - iron, with resilient seat, Class 150; [EPDM][NBR] seat.
27. Check valves, single-plate type - iron, with resilient seat, Class 250; [EPDM][NBR] seat.
28. Check valves, dual-plate type - iron, with resilient seat, Class 250; [EPDM][NBR] seat.
29. Check valves, dual-plate type - iron, with resilient seat, Class 300; [EPDM][NBR] seat.

C. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):

1. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
2. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

D. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):

1. Check valves, swing type, grooved ends - iron, 300 CWP.

3.33 LOW-PRESSURE STEAM CHECK VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS**A. Pipe NPS 2 (DN 50) and Smaller:**

1. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
2. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
3. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.

4. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
5. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

3.34 HIGH-PRESSURE STEAM CHECK VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2 (DN 50) and Smaller:

1. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
2. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
3. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
4. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
5. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

3.35 STEAM-CONDENSATE CHECK VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
2. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
3. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
4. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
5. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

3.36 PUMP-DISCHARGE CHECK VALVE SCHEDULE

A. Chilled-Water Pump Discharge:

1. Pipe NPS 2 (DN 50) and Smaller:

- a. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
- b. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
- c. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
- d. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.

2. Pipe NPS 2-1/2 (DN 65) and Larger:

- a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
- b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

- c. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
- d. Check valves, center guided - iron, globe, with metal seat, Class 125.
- e. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
- f. Check valves, center guided - iron, globe, with metal seat, Class 150.
- g. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
- h. Check valves, center guided - iron, globe, with metal seat, Class 250.
- i. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
- j. Check valves, center guided - iron, globe, with metal seat, Class 300.
- k. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; [EPDM][NBR] seat.
- l. Check valves, center guided - iron, globe, with resilient seat, Class 125; [EPDM][NBR] seat.
- m. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; [EPDM][NBR] seat.
- n. Check valves, center guided - iron, globe, with resilient seat, Class 150; [EPDM][NBR] seat.
- o. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; [EPDM][NBR] seat.
- p. Check valves, center guided - iron, globe, with resilient seat, Class 250; [EPDM][NBR] seat.
- q. Check valves, center guided - iron, compact wafer, with resilient seat, Class 300; [EPDM][NBR] seat.
- r. Check valves, center guided - iron, globe, with resilient seat, Class 300; [EPDM][NBR] seat.

3. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):

- a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
- b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

4. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):

- a. Check valves, swing type, grooved ends - iron, 300 CWP.

B. Condenser-Water Pump Discharge:

1. Pipe NPS 2 (DN 50) and Smaller:

- a. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
- b. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
- c. Check valves, swing type, threaded or soldered ends - bronze, with bronze disc, Class 150.
- d. Check valves, swing type, threaded or soldered ends - bronze, with nonmetallic disc, Class 150.

2. Pipe NPS 2-1/2 (DN 65) and Larger:

- a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
- b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
- c. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
- d. Check valves, center guided - iron, globe, with metal seat, Class 125.

- e. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
 - f. Check valves, center guided - iron, globe, with metal seat, Class 150.
 - g. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
 - h. Check valves, center guided - iron, globe, with metal seat, Class 250.
 - i. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
 - j. Check valves, center guided - iron, globe, with metal seat, Class 300.
 - k. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; [EPDM][NBR] seat.
 - l. Check valves, center guided - iron, globe, with resilient seat, Class 125; [EPDM][NBR] seat.
 - m. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; [EPDM][NBR] seat.
 - n. Check valves, center guided - iron, globe, with resilient seat, Class 150; [EPDM][NBR] seat.
 - o. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; [EPDM][NBR] seat.
 - p. Check valves, center guided - iron, globe, with resilient seat, Class 250; [EPDM][NBR] seat.
 - q. Check valves, center guided - iron, compact wafer, with resilient seat, Class 300; [EPDM][NBR] seat.
 - r. Check valves, center guided - iron, globe, with resilient seat, Class 300; [EPDM][NBR] seat.
3. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):
- a. Check valves, swing type, grooved-end - iron, 300 CWP.
- C. Heating-Water Pump Discharge:
1. Pipe NPS 2 (DN 50) and Smaller:
- a. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 - b. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
 - c. Check valves, swing type, threaded or soldered ends - bronze, with bronze disc, Class 150.
 - d. Check valves, swing type, threaded or soldered ends - bronze, with nonmetallic disc, Class 150.
2. Pipe NPS 2-1/2 (DN 65) and Larger:
- a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 - b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
 - c. Check valves, center guided - iron, spring loaded, compact wafer, with metal seat, Class 125.
 - d. Check valves, center guided - iron, spring loaded, globe, with metal seat, Class 125.
 - e. Check valves, center guided - iron, spring loaded, compact wafer, with metal seat, Class 150.
 - f. Check valves, center guided - iron, spring loaded, globe, with metal seat, Class 150.
 - g. Check valves, center guided - iron, spring loaded, compact wafer, with metal seat, Class 250.
 - h. Check valves, center guided - iron, spring loaded, globe, with metal seat, Class 250.
 - i. Check valves, center guided - iron, spring loaded, compact wafer, with metal seat, Class 300.
 - j. Check valves, center guided - iron, spring loaded, globe, with metal seat, Class 300.

- k. Check valves, center guided - iron, spring loaded, compact wafer, with resilient seat, Class 125; [EPDM][NBR] seat.
 - l. Check valves, center guided - iron, spring loaded, globe, with resilient seat, Class 125; [EPDM][NBR] seat.
 - m. Check valves, center guided - iron, spring loaded, compact wafer, with resilient seat, Class 150; [EPDM][NBR] seat.
 - n. Check valves, center guided - iron, spring loaded, globe, with resilient seat, Class 150; [EPDM][NBR] seat.
 - o. Check valves, center guided - iron, spring loaded, compact wafer, with resilient seat, Class 250; [EPDM][NBR] seat.
 - p. Check valves, center guided - iron, spring loaded, globe, with resilient seat, Class 250; [EPDM][NBR] seat.
 - q. Check valves, center guided - iron, spring loaded, compact wafer, with resilient seat, Class 300; [EPDM][NBR] seat.
 - r. Check valves, center guided - iron, spring loaded, globe, with resilient seat, Class 300; [EPDM][NBR] seat.
3. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):
- a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 - b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
4. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):
- a. Check valves, swing type, grooved ends - iron, 300 CWP.
- D. Steam-Condensate Pump Discharge:
1. Pipe NPS 2 (DN 50) and Smaller:
- a. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 - b. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
 - c. Check valves, swing type, threaded - bronze, with bronze disc, Class 150.
 - d. Check valves, swing type, threaded - bronze, with nonmetallic disc, Class 150.
2. Pipe NPS 2-1/2 (DN 65) and Larger for Steam Condensate Pumps:
- a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 - b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
 - c. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
 - d. Check valves, center guided - iron, globe, with metal seat, Class 125.
 - e. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
 - f. Check valves, center guided - iron, globe, with metal seat, Class 150.
 - g. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
 - h. Check valves, center guided - iron, globe, with metal seat, Class 250.
 - i. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
 - j. Check valves, center guided - iron, globe, with metal seat, Class 300.
 - k. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; [EPDM][NBR] seat.
 - l. Check valves, center guided - iron, globe, with resilient seat, Class 125; [EPDM][NBR] seat.

- m. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; **[EPDM][NBR]** seat.
 - n. Check valves, center guided - iron, globe, with resilient seat, Class 150; **[EPDM][NBR]** seat.
 - o. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; **[EPDM][NBR]** seat.
 - p. Check valves, center guided - iron, globe, with resilient seat, Class 250; **[EPDM][NBR]** seat.
 - q. Check valves, center guided - iron, compact wafer, with resilient seat, Class 300; **[EPDM][NBR]** seat.
 - r. Check valves, center guided - iron, globe, with resilient seat, Class 300; **[EPDM][NBR]** seat.
3. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300) for Steam Condensate Pumps:
- a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 - b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

3.37 CHILLED-WATER GATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

- 1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; **[threaded][soldered]** ends.
- 2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; **[threaded][soldered]** ends.
- 3. Gate valves, threaded ends - bronze, NRS, Class 150.
- 4. Gate valves, threaded ends - bronze, RS, Class 150.
- 5. Gate valves, press ends - bronze; **[RS][NRS]**.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

- 1. Gate valves, flanged ends - iron, NRS, Class 125.
- 2. Gate valves, flanged ends - iron, OS&Y, Class 125.
- 3. Gate valves, flanged ends - iron, NRS, Class 250.
- 4. Gate valves, flanged ends - iron, OS&Y, Class 250.

C. CPVC Pipe:

- 1. CPVC Gate Valve: **[NPS 2 (DN 50) and smaller][NPS 4 (DN 100) and smaller][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>**.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: **[Socket][or][threaded]**.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and Larger: **[Socket][Socket or threaded][Threaded][Flanged]**.

D. PVC Pipe:

- 1. PVC Gate Valve: **[NPS 2 (DN 50) and smaller][NPS 4 (DN 100)][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure> at [73 deg F (23 deg C)]<Insert temperature>**.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: **[Socket][or][threaded]**.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **[Socket][Socket or threaded][Threaded][Flanged]**.

3.38 CONDENSER-WATER GATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; **[threaded][soldered]** ends.
2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; **[threaded][soldered]** ends.
3. Gate valves, threaded ends - bronze, NRS, Class 150.
4. Gate valves, threaded ends - bronze, RS, Class 150.
5. Gate valves, press ends - bronze; **[RS][NRS]**.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Gate valves, flanged ends - iron, NRS, Class 125.
2. Gate valves, flanged ends - iron, OS&Y, Class 125.
3. Gate valves, flanged ends - iron, NRS, Class 250.
4. Gate valves, flanged ends - iron, OS&Y, Class 250.

C. CPVC Pipe:

1. CPVC Gate Valve: **[NPS 2 (DN 50) and smaller][NPS 4 (DN 100) and smaller][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure>** at **[73 deg F (23 deg C)]<Insert temperature>**.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: **[Socket][or][threaded]**.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and Larger: **[Socket][Socket or threaded][Threaded][Flanged]**.

D. PVC Pipe:

1. PVC Gate Valve: **[NPS 2 (DN 50) and smaller][NPS 4 (DN 100)][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert pressure>** at **[73 deg F (23 deg C)]<Insert temperature>**.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: **[Socket][or][threaded]**.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): **[Socket][Socket or threaded][Threaded][Flanged]**.

3.39 HEATING-WATER GATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; **[threaded][soldered]** ends.
2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; **[threaded][soldered]** ends.
3. Gate valves, threaded ends - bronze, NRS, Class 150.
4. Gate valves, threaded ends - bronze, RS, Class 150.
5. Gate valves, press ends - bronze; **[RS][NRS]**.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Gate valves, flanged ends - iron, NRS, Class 125.
2. Gate valves, flanged ends - iron, OS&Y, Class 125.
3. Gate valves, flanged ends - iron, NRS, Class 250.
4. Gate valves, flanged ends - iron, OS&Y, Class 250.

3.40 LOW-PRESSURE STEAM GATE VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

- A. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; threaded ends.
 - 2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; threaded ends.
 - 3. Gate valves, threaded ends - bronze, NRS, Class 150.
 - 4. Gate valves, threaded ends - bronze, RS, Class 150.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Gate valves, flanged ends - iron, NRS, Class 125.
 - 2. Gate valves, flanged ends - iron, OS&Y, Class 125.
 - 3. Gate valves, flanged ends - iron, NRS, Class 250.
 - 4. Gate valves, flanged ends - iron, OS&Y, Class 250.

3.41 HIGH-PRESSURE STEAM GATE VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

- A. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; threaded ends.
 - 2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; threaded ends.
 - 3. Gate valves, threaded ends - bronze, NRS, Class 150.
 - 4. Gate valves, threaded ends - bronze, RS, Class 150.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Gate valves, flanged ends - iron, NRS, Class 125.
 - 2. Gate valves, flanged ends - iron, OS&Y, Class 125.
 - 3. Gate valves, flanged ends - iron, NRS, Class 250.
 - 4. Gate valves, flanged ends - iron, OS&Y, Class 250.

3.42 STEAM-CONDENSATE GATE VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; threaded ends.
 - 2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; threaded ends.
 - 3. Gate valves, threaded ends - bronze, NRS, Class 150.
 - 4. Gate valves, threaded ends - bronze, RS, Class 150.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Gate valves, flanged ends - iron, NRS, Class 125.
 - 2. Gate valves, flanged ends - iron, OS&Y, Class 125.
 - 3. Gate valves, flanged ends - iron, NRS, Class 250.
 - 4. Gate valves, flanged ends - iron, OS&Y, Class 250.

3.43 CHILLED-WATER PLUG VALVE SCHEDULE

- A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Plug valves, lubricated type, threaded ends - Class 125.
2. Plug valves, lubricated type, flanged ends - Class 125; **[Type I single gland][or][Type II regular gland]**.
3. Plug valves, lubricated type, threaded ends - cylindrical, Class 125.
4. Plug valves, lubricated type, flanged ends - cylindrical, Class 125.
5. Plug valves, lubricated type, threaded ends - Class 250; **[Type I single gland][or][Type II regular gland]**.
6. Plug valves, lubricated type, flanged ends - Class 250; **[Type I single gland][or][Type II regular gland]**.
7. Plug valves, lubricated type, threaded ends - cylindrical, Class 250.
8. Plug valves, lubricated type, flanged ends - cylindrical, Class 250.
9. Plug valves, eccentric type, flanged ends - with resilient seat, 175 CWP.

3.44 CONDENSER-WATER PLUG VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Plug valves, lubricated type, threaded ends - Class 125.
2. Plug valves, lubricated type, flanged ends - Class 125; **[Type I single gland][or][Type II regular gland]**.
3. Plug valves, lubricated type, threaded ends - cylindrical, Class 125.
4. Plug valves, lubricated type, flanged ends - cylindrical, Class 125.
5. Plug valves, lubricated type, threaded ends - Class 250; **[Type I single gland][or][Type II regular gland]**.
6. Plug valves, lubricated type, flanged ends - Class 250; **[Type I single gland][or][Type II regular gland]**.
7. Plug valves, lubricated type, threaded ends - cylindrical, Class 250.
8. Plug valves, lubricated type, flanged ends - cylindrical, Class 250.
9. Plug valves, eccentric type, flanged ends - with resilient seat, 175 CWP.

3.45 HEATING-WATER PLUG VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Plug valves, lubricated type, threaded ends - Class 125.
2. Plug valves, lubricated type, flanged ends - Class 125; **[Type I single gland][or][Type II regular gland]**.
3. Plug valves, lubricated type, threaded ends - cylindrical, Class 125.
4. Plug valves, lubricated type, flanged ends - cylindrical, Class 125.
5. Plug valves, lubricated type, threaded ends - Class 250; **[Type I single gland][or][Type II regular gland]**.
6. Plug valves, lubricated type, flanged ends - Class 250; **[Type I single gland][or][Type II regular gland]**.
7. Plug valves, lubricated type, threaded ends - cylindrical, Class 250.
8. Plug valves, lubricated type, flanged ends - cylindrical, Class 250.
9. Plug valves, eccentric type, flanged ends - with resilient seat, 175 CWP.

3.46 STEAM-CONDENSATE PLUG VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Plug valves, lubricated type, threaded ends - Class 125.

2. Plug valves, lubricated type, flanged ends - Class 125; **[Type I single gland][or][Type II regular gland]**.
3. Plug valves, lubricated type, threaded ends - cylindrical, Class 125.
4. Plug valves, lubricated type, flanged ends - cylindrical, Class 125.
5. Plug valves, lubricated type, threaded ends - Class 250; **[Type I single gland][or][Type II regular gland]**.
6. Plug valves, lubricated type, flanged ends - Class 250; **[Type I single gland][or][Type II regular gland]**.
7. Plug valves, lubricated type, threaded ends - cylindrical, Class 250.
8. Plug valves, lubricated type, flanged ends - cylindrical, Class 250.
9. Plug valves, eccentric type, flanged ends - with resilient seat, 175 CWP.

END OF SECTION 23 05 23 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 05 23 00	22 05 23 00	General-Duty Valves for Plumbing Piping
23 05 23 00	22 05 76 00	Storm Drainage Piping Specialties
23 05 23 00	22 15 13 00	General-Service Compressed-Air Piping
23 05 23 00	23 05 00 00a	Coatings for HVAC
23 05 23 00	23 21 13 00	Hydronic Piping
23 05 23 00	23 21 23 00	Hydronic Pumps
23 05 23 00	23 23 00 00	Refrigerant Piping



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 05 29 00 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe hangers and supports - carbon steel.
2. Pipe hangers and supports - stainless steel.
3. Pipe/tube hangers and supports - copper.
4. Pipe hangers - metal, trapeze type.
5. Pipe hangers - FRP.
6. Strut support system - metal, rod type.
7. Strut support system - metal, cable type.
8. Strut support system - FRP.
9. Strut support system - rooftop-mounted pipe stand, compact.
10. Strut support system - rooftop-mounted pipe stand, single base, single pipe, low profile.
11. Strut support system - rooftop-mounted pipe stand, single base, single pipe, high profile.
12. Strut support system - rooftop-mounted pipe stand, curb-mounted type.
13. Strut support system - rooftop-mounted pipe stand, multiple pipe, high profile.
14. Thermal hanger shield inserts.
15. Fastener system - powder-actuated fasteners.
16. Fastener system - mechanical expansion anchors.
17. Equipment supports.
18. Equipment stands - outdoor type.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230500 "Common Work Results for HVAC" for pipe guides and anchors.
3. **[Section 230548 "Vibration and Seismic Controls for HVAC"]** **[Section 230548.13 "Vibration Controls for HVAC"]** for vibration isolation devices.
4. **[Section 233113 "Metal Ducts"]** **[and]** **[Section 233116 "Nonmetal Ducts"]** for duct hangers and supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: **[Signed and sealed by a qualified professional engineer.]** Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal strut support systems.
3. Rooftop-mounted strut support systems.
4. FRP strut support systems.
5. Pipe stands.
6. Equipment supports.



- C. Delegated Design Submittals: For **[trapeze hangers]** **[and]** **[strut support systems]** indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication/assembly and design calculations for **[trapeze hangers]** **[strut support systems]**.
 - 2. Detail fabrication/assembly and design calculations for each type of strut support system, by the manufacturer's technical representative.
- D. Sustainable Design Submittals:
 - 1. <Double click to insert sustainable design text for recycled content.>

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators in accordance with 2021 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design **[trapeze hangers]** **[, strut support systems,]** **[and]** equipment supports.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment are to withstand the effects of gravity loads and stresses within limits and under conditions indicated in accordance with **[ASCE/SEI 7]** **<Insert requirement>**.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 - 3. Design seismic-restraint hangers and supports for piping and equipment **[and obtain approval from authorities having jurisdiction]**.

2.2 PIPE HANGERS AND SUPPORTS - METAL

- A. Pipe Hangers and Supports - Carbon Steel:
 - 1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
 - 2. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.

3. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
4. Nonmetallic Coatings: Plastic coated, or epoxy powder coated.
5. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
6. Hanger Rods: Continuous-thread rod, nuts, and washers made of **[carbon steel]** **[stainless steel]** **<Insert material>**.

B. Pipe Hangers and Supports - Stainless Steel:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
3. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of **[stainless steel]** **<Insert material>**.

C. Pipe/Tube Hangers and Supports - Copper:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of **[copper-plated steel]** **[stainless steel]** **<Insert material>**.

2.3 PIPE HANGERS - METAL, TRAPEZE TYPE

- A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 PIPE HANGERS - FRP

A. Pipe Hangers - FRP, Clevis Type:

1. Description: Similar to MSS SP-58, Type 1, factory-fabricated steel pipe hanger except hanger is made of fiberglass-reinforced plastic resin.
2. Hanger Rods: Continuous-thread **[stainless steel]** **<Insert material>** rod, washer, and nuts made of **[FRP]** **[polyurethane]** **[or]** **[stainless steel]** **<Insert material>**.
3. Flammability: ASTM D635, ASTM E84, and UL 94.

B. Pipe Hangers - FRP, Strap Type:

1. Description: Similar to MSS SP-58, Type 9 or Type 10 steel pipe hanger except hanger is made of fiberglass-reinforced plastic resin.
 - a. Flammability: ASTM D635, ASTM E84, and UL 94.
2. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of **[stainless steel]** **<Insert material>**.

2.5 STRUT SUPPORT SYSTEMS - METAL

A. Strut Support System - Metal, Rod Type:



1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Factory-fabricated pipe-support assembly made of steel channels, vertical metal support rods, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Struts: Continuous slotted **[carbon-steel] [stainless steel, Type 304] [stainless steel, Type 316] [extruded-aluminum]** **<Insert material> [channel with inturned lips] [or] [angle] <Insert strut type>**.
5. Strut Width: Selected for applicable load criteria.
6. Strut Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of **[galvanized steel] [stainless steel] <Insert material>**.
8. Metallic Coating: **[Plain] [Pregalvanized G90 (Z275)] [Electroplated zinc] [Hot-dip galvanized] [Gold (yellow zinc dichromate) galvanized]**.
9. Paint Coating: **[Green epoxy, acrylic, or urethane] <Insert paint type>**.
10. Plastic Coating: **[PVC] <Insert plastic type>**.
11. Combination Coating: **<Insert combination coating>**.

B. Strut Support System - Metal, Cable Type:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Factory-fabricated pipe-support system, consisting of cable pipe clamps and associated vibration isolation rubber pads, slotted channel brackets, wire rope suspension components, and associated accessories for a complete piping suspension system; no tools required for manual assembly in the field to support multiple parallel pipe routing.
3. Standards:
 - a. ICC-ES PMG Product Certificate.
 - b. Brackets: Fire-rated, tested to F120 in accordance with BS EN 1363-1:2020.
4. Components:
 - a. Pipe Clamps: Size-adjustable **[standard] [compact] [and] [field-height-adjustable]** clamps with **[rubber pad, 14 dBA noise reduction] [and] [large rubber pad, 18 dBA noise reduction] [acoustic rubber pad, 23 dBA noise reduction]**; with sleeve to prevent galvanic corrosion.
 - b. Brackets: Slotted steel channels furnished in pre-cut lengths to suit specific system application for Project. **<Insert type of coating>**
 - c. Suspension Components: Hanging cables with adjustable fastener; can be pre-installed on the brackets using pre-fitted washer/nuts or retention clips.
 - 1) Wire Rope: High tensile steel wire rope, complying with ASTM A1023/A1023M, ASTM A641/A641M Class A zinc coating; **[7 by 7] [and] [7 x 19]** cross-sectional construction; having a tensile strength of 256,000 psi (1,770 N per sq mm); lengths, diameters, and wire construction **[to accommodate design loads] [indicated on Shop Drawings]**.
 - a) Locking screw/release button.
 - b) Foot attachment type to suit application.
 - c) End Fix Type: **[Loop] [, strap hook] [, eyelet] [or] <Insert type> <as required to suit application>**.
 - d. Adjustable Fastener: Mild steel (Type EN1A), bright zinc plated, one-channel body; encasing a series of Type 302 stainless steel springs with serrated self-locking Grade 40

chrome steel balls, adjustable by means of an integrated mechanism, capable of accommodating load of [100 lb (45 kg)] [200 lb (90 kg)] [500 lb (225 kg)].

2.6 STRUT SUPPORT SYSTEMS - FRP

A. Strut Support System - FRP:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description: Structural-grade, factory-formed, glass-fiber-resin channels and angles for supporting multiple parallel pipes.
 - a. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - b. Struts: Continuous slotted fiberglass-reinforced plastic channel with inturned lips.
 - c. Strut Width: Selected for applicable load criteria.
 - d. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
 - e. Fitting and Accessory Materials: Same as those for channels and angles[, **except metal items may be stainless steel**].
 - f. Rated Strength: Selected to suit applicable load criteria.
 - g. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

2.7 STRUT SUPPORT SYSTEMS - ROOFTOP MOUNTED

A. Strut Support System - Rooftop-Mounted Pipe Stand, Compact:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Shop-fabricated assembly made of manufactured corrosion-resistant components to support rooftop-mounted piping.
3. Configuration: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
4. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
5. [<Double click to insert sustainable design text for recycled content.>](#)
6. Hardware: Galvanized steel or polycarbonate.
7. Accessories: Protection pads.

B. Strut Support System - Rooftop-Mounted Pipe Stand, Single Base, Single Pipe, Low Profile:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Shop-fabricated assembly made of manufactured corrosion-resistant components to support rooftop-mounted piping.
3. Configuration: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
4. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
5. [<Double click to insert sustainable design text for recycled content.>](#)
6. Vertical Members: Two, [**galvanized-steel**] [**stainless steel**], continuous-thread 1/2-inch (12-mm) rods.



7. Horizontal Member: Adjustable-height, **[galvanized-steel]** **[stainless steel]** pipe support channels.
8. Pipe Supports: **[Roller]** **[Strut clamps]** **[Clevis hanger]** **[Swivel hanger]**.
9. Hardware: **[Galvanized]** **[Stainless]** steel.
10. Accessories: Protection pads.
11. Height: **[12 inches (300 mm) above roof]** **<Insert lesser dimension above roof>**.

C. Strut Support System - Rooftop-Mounted Pipe Stand, Single Base, Single Pipe, High Profile:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
3. Base: Single vulcanized rubber or molded polypropylene.
4. <Double click to insert sustainable design text for recycled content.>
5. Vertical Members: Two, **[galvanized-steel]** **[stainless steel]**, continuous-thread 1/2-inch (12-mm) rods.
6. Horizontal Member: One, adjustable-height, **[galvanized-steel]** **[or]** **[stainless steel]** pipe support slotted channel or plate.
7. Pipe Supports: **[Roller]** **[Clevis hanger]** **[Swivel hanger]**.
8. Hardware: **[Galvanized]** **[Stainless]** steel.
9. Accessories: Protection pads, 1/2-inch (12-mm) continuous-thread **[galvanized-steel]** **[stainless steel]** rod.
10. Height: **[36 inches (900 mm) above roof]** **<Insert lesser dimension above roof>**.

D. Strut Support System - Rooftop-Mounted Pipe Stand, Multiple Pipe, High Profile:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
3. Bases: Two or more; **[vulcanized rubber]** **[molded polypropylene]** **<Insert material>**.
4. <Double click to insert sustainable design text for recycled content.>
5. Vertical Members: Two or more, **[galvanized-steel]** **[stainless steel]** channels.
6. Horizontal Members: One or more, adjustable-height, **[galvanized-steel]** **[stainless steel]** pipe support.
7. Pipe Supports: **[Roller]** **[Strut clamps]** **[Clevis hanger]** **[Swivel hanger]**.
8. Hardware: **[Galvanized]** **[Stainless]** steel.
9. Accessories: Protection pads[, 1/2-inch (12-mm) continuous-thread rod].
10. Height: **[36 inches (900 mm) above roof]** **<Insert lesser dimension above roof>**.

E. Strut Support System - Rooftop-Mounted Pipe Stand, Curb-Mounted Type: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.8 THERMAL HANGER SHIELD INSERTS

A. Thermal Hanger Shield Inserts:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Insulation-Insert Material for Cold Piping: **[ASTM C552, Type II cellular glass with 100 psi (688 kPa)]** **[or]** **[ASTM C591, Type VI, Grade 1 polyisocyanurate with 125 psi (862 kPa)]** **<Insert insulation type and compressive strength>** minimum compressive strength and vapor barrier.
3. Insulation-Insert Material for Hot Piping: **[Water-repellent-treated, ASTM C533, Type I calcium silicate with 100 psi (688 kPa)]** **[ASTM C552, Type II cellular glass with 100 psi (688 kPa)]**

[or] [ASTM C591, Type VI, Grade 1 polyisocyanurate with 125 psi (862 kPa)] <Insert insulation type and compressive strength> minimum compressive strength.

4. For Trapeze or Clamped Systems: Insert and shield are to cover entire circumference of pipe.
5. For Clevis or Band Hangers: Insert and shield are to cover bottom 180 degrees of pipe.
6. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.9 FASTENER SYSTEMS

- A. Fastener System - Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities required for supported loads and building materials where used.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

- B. Fastener System - Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities required for supported loads and building materials where used.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Indoor Applications: **[Zinc-plated]** [or] **[stainless]** steel.
3. Outdoor Applications: Stainless steel.

2.10 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.11 EQUIPMENT STANDS, OUTDOOR TYPE

- A. Equipment Stands, Outdoor Type:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground- or roof-supported outdoor equipment components, without roof membrane penetration, in a prefabricated system that can be modularly assembled on site.
3. Foot Material: Rubber or polypropylene.
4. Rails Material: Hot dip galvanized carbon steel.
5. Wind/Sliding Load Resistance: Up to **[100 mph (44 mps)]** <Insert value> minimum.

2.12 MATERIALS

- A. Aluminum: ASTM B221 (ASTM B221M).
- B. Carbon Steel: ASTM A1011/A1011M.
- C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.
- D. Stainless Steel: ASTM A240/A240M.



- E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.
- F. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000 psi (34.5 MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry static loads within specified loading limits. Minimum static design load used for strength determination is to include weight of supported components plus **[200 lb (90 kg)]** **<Insert value>**.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

- A. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- B. Install lateral bracing with pipe hangers and supports to prevent swaying.
- C. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, **[NPS 2-1/2 (DN 65)]** **<Insert pipe size>** and larger **[and at changes in direction of piping]**. Coordinate location of concrete inserts before concrete is placed.
- D. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- E. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- F. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

- a. Thermal hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
- 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields are to span an arc of 180 degrees.
 - a. Thermal hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
- 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
- 5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
- G. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- H. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate in accordance with ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel in accordance with AWS D1.1/D1.1M.
- I. FRP Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.
- J. Strut System Installation: **[Metal, rod type] [Metal, cable type] [FRP]**. Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems. Install in accordance with manufacturer's written installation instructions.
- K. Thermal Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- L. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick after concrete is placed and cured. Use installers that are trained and certified **[by power tool manufacturer] [in accordance with the AHJ]**.
 - 2. Install mechanical-expansion anchors after concrete is placed and completely cured.
 - 3. Install fasteners in accordance with manufacturer's written instructions.
 - 4. Install lag screw wood fasteners in accordance with manufacturer's written instructions.
- M. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- N. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- O. Equipment Support Installation:
1. Fabricate from welded-structural-steel shapes.
 2. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
 3. Grouting: Place grout under supports for floor-mounted equipment, and make bearing surface smooth.
 4. Provide lateral bracing, to prevent swaying.

3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for **[trapeze pipe hangers] [and] [equipment supports]**.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; methods used in correcting welding work; and with the following:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to **[1-1/2 inches (40 mm)] <Insert dimension>**.

3.5 PAINTING

- A. Touchup:
1. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

- a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
2. Comply with requirements in **[Section 099113 "Exterior Painting"] [Section 099123 "Interior Painting"] [and] [Section 099600 "High-Performance Coatings"] <Insert painting Section(s)>** for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
3. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel **[pipe hangers and supports] [metal trapeze pipe hangers] [and] [metal framing systems]** and attachments for general service applications.
- F. Use **[stainless steel pipe hangers] [FRP pipe hangers] [and] [FRP strut systems] and [stainless steel] [or] [corrosion-resistant]** attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and **[copper] [or] [stainless steel]** attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal hanger shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).

8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.
- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal Hanger Shield Inserts: For supporting insulated pipe.
- O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for



erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

- a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- Q. Use **[powder-actuated fasteners]** **[or]** **[mechanical-expansion anchors]** instead of building attachments where required in concrete construction.

END OF SECTION 23 05 29 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 05 29 00	21 05 00 00	Common Work Results for Fire Suppression
23 05 29 00	22 05 00 00	Common Work Results for Plumbing
23 05 29 00	22 05 29 00	Hangers and Supports for Plumbing Piping and Equipment
23 05 29 00	22 05 76 00	Storm Drainage Piping Specialties
23 05 29 00	23 05 00 00	Common Work Results for HVAC
23 05 29 00	23 05 00 00a	Coatings for HVAC



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 05 33 00 - HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes heat tracing for freeze prevention of HVAC piping with self-regulating, parallel-resistance, electric heating cables:
- B. Related Requirements:
 - 1. Section 210533 "Heat Tracing for Fire-Suppression Piping."
 - 2. Section 220533 "Heat Tracing for Plumbing Piping."

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
- B. Shop Drawings: For electric heating cable.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For electric heating cables and controls to include in operation and maintenance manuals.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.
 - 1. Warranty Period: [Three][Five][10]<Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[BriskHeat]**
2. **[Chromalox, Inc.]**
3. **[Delta-Therm Corporation]**
4. **[EasyHeat; Emerson Electric Co., Commercial and Residential Solutions]**
5. **[RAYCHEM; brand of nVent Electrical plc]**
6. **[Thermon, Inc.]**
7. **[Trasor Corp.]**
8. **[WarmlyYours Radiant, Inc.]**
9. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[BriskHeat]**
2. **[Chromalox, Inc.]**
3. **[Delta-Therm Corporation]**
4. **[EasyHeat; Emerson Electric Co., Commercial and Residential Solutions]**
5. **[RAYCHEM; brand of nVent Electrical plc]**
6. **[Thermon, Inc.]**
7. **[Trasor Corp.]**
8. **[WarmlyYours Radiant, Inc.]**
9. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain all heat tracing from one manufacturer.

- D. Standard: IEEE 515.1.

- E. Heating Element: Pair of parallel **[No. 16][No. 18]** AWG, **[tinned][nickel-coated]**, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length.

- F. Electrical Insulating Jacket: Flame-retardant polyolefin.

- G. Grounding Cover: **[Copper][Tinned-copper]** braid.

- H. Cable Cover: **[Tinned-copper][Stainless steel]** braid **[and polyolefin outer jacket with ultraviolet inhibitor]**.

- I. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable is to be capable of crossing over itself once without overheating.

- J. Maximum Operating Temperature (Power On): **[150 deg F (65 deg C)]<Insert temperature>**.

- K. Maximum Exposure Temperature (Power Off): **[185 deg F (85 deg C)]<Insert temperature>**.

- L. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- M. Capacities and Characteristics:
 - 1. Maximum Heat Output: [3 W/ft. (9.8 W/m)][5 W/ft. (16.4 W/m)][8 W/ft. (26 W/m)][10 W/ft. (32.8 W/m)][12 W/ft. (39.4 W/m)]<Insert value>.
 - 2. Piping Diameter: <Insert NPS (DN)>.
 - 3. Number of Parallel Cables: <Insert number>.
 - 4. Spiral Wrap Pitch: <Insert inches (mm)>.
 - 5. Electrical Characteristics for Single-Circuit Connection:
 - a. Volts: [120][208][240][277][480]<Insert number> V.
 - b. Phase: [1][3]<Insert value>.
 - c. Hertz: [60 Hz]<Insert number> Hz.
 - d. Full-Load Amperes: <Insert number> A.
 - e. Minimum Circuit Ampacity: <Insert number> A.
 - f. Maximum Overcurrent Protection: <Insert number> A.

2.2 CONTROLS

- A. Pipe-Mounted Thermostats for Freeze Protection:
 - 1. Remote bulb temperature-control unit with adjustable range from [30 to 50 deg F (minus 1 to plus 10 deg C)]<Insert temperature range>.
 - 2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
 - 3. Remote temperature-sensing bulb on capillary, resistance temperature device, or thermistor for directly sensing ambient air or pipe-wall temperature.
 - 4. Corrosion-resistant, waterproof control enclosure.
- B. Control Panel:
 - 1. [Microprocessor-based][Automatic] control with manual on, automatic, and standby/reset switch.
 - 2. Remote temperature sensors sense outside air temperature; programmable to energize the cable when temperature falls below [34 to 44 deg F (1 to 7 deg C)]<Insert temperature range>.
 - 3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
 - 4. Minimum 30 A contactor to energize cable or close other contactors.
 - 5. Ground-fault protection.
 - 6. Single-point control of heat tracing for freeze protection.
 - 7. Provide communication ports with contacts, RS485, or Ethernet interface for remote monitoring and alarm by central HVAC-control system. Coordinate type of connection ports with Section 230923 "Direct Digital Control (DDC) System for HVAC."

2.3 ACCESSORIES

- A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
- B. Warning Labels: See Section 230553 "Identification for HVAC Piping and Equipment."



- C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least **3 mils (0.08 mm)** thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
 - 1. Width for Markers on Pipes with OD, Including Insulation, Less Than **6 Inches (150 mm)**: **3/4 inch (19 mm)** minimum.
 - 2. Width for Markers on Pipes with OD, Including Insulation, **6 Inches (150 mm)** or Larger: **1-1/2 inches (38 mm)** minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.
 - 1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install electric heating cable at locations indicated and in accordance with NFPA 70.
- B. Install electric heating cable across expansion, construction, and control joints in accordance with manufacturer's written instructions; use cable-protection conduit and slack cable to allow movement without damage to cable.
- C. Install electric heating cables after piping has been tested and before insulation is installed.
- D. Install electric heating cables in accordance with IEEE 515.1.
- E. Install insulation over piping with electric cables in accordance with Section 230719 "HVAC Piping Insulation."
- F. Install warning tape on piping insulation where piping is equipped with electric heating cables.
- G. Set field-adjustable switches and circuit-breaker trip ranges.
- H. Install temperature-control units in an accessible location and in accordance with manufacturer's written instructions. Locate sensing bulbs to sense outside air temperature in a location where it will not be affected by direct sunlight or other heat sources.
- I. Install control panels and distribution panels where indicated and in accordance with manufacturer's written instructions.
- J. Install outside air and pipe temperature sensors.



3.3 ELECTRICAL CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Connect temperature-control unit to interrupt power supply to electric heating cable when outside air is above set point.
- D. Connect remote electronic temperature sensors.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Perform tests after cable installation but before application of coverings, such as insulation, wall or ceiling construction, or concrete.
 - 2. Test cables for electrical continuity and insulation integrity before energizing.
 - 3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
- D. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.
- E. Cables will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.5 PROTECTION

- A. Protect installed heating cables, including nonheating leads, from damage.
- B. Remove and replace damaged heat-tracing cables.

END OF SECTION 23 05 33 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 05 33 00	23 05 00 00a	Coatings for HVAC



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 05 48 00 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient support.
9. Resilient pipe guides.
10. Air-spring isolators.
11. Restrained-air-spring isolators.
12. Elastomeric hangers.
13. Spring hangers.
14. Snubbers.
15. Restraints - rigid type.
16. Restraints - cable type.
17. Restraint accessories.
18. Post-installed concrete anchors.
19. Concrete inserts.
20. Vibration isolation equipment bases.
21. Seismically restrained isolation roof-curb rails.

B. Related Requirements:

1. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components.
2. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" specifies devices for fire-suppression equipment and systems.
3. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" specifies devices for plumbing equipment and systems.

1.2 DEFINITIONS

- A. Designated Seismic System: An architectural, mechanical, electrical, plumbing, or fire protection system and its components for which the component importance factor is greater than 1.0 when determined in accordance with Section 018123 "Facility Seismic and Wind Criteria."
- B. IBC: International Building Code.
- C. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.3 DELEGATED DESIGN SERVICES

- A. Delegated Design Professional: Engage qualified professional structural engineer to design seismic and wind restraints.

1.4 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Include load rating for each seismic-[**and wind**]-restraint device.
3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-[**and wind**]-restraint component.
4. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by **[ICC-ES product listing][UL product listing][FM Approvals][an evaluation service member of ICC-ES][OSHDP][an agency acceptable to authorities having jurisdiction]**.
5. Annotate to indicate application of each product submitted and compliance with requirements.
6. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
3. Show coordination of seismic[**and wind**] restraints for components with other systems and equipment in the vicinity, including other supports and other seismic restraints.

C. Delegated Design Submittals:

1. All delegated design and submittals for **[seismic][and][wind]** restraints must be signed and sealed by a qualified professional structural engineer responsible for their preparation. Structural engineer is to possess qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including design of seismic and wind restraints, equipment hangers and supports, and concrete attachments.
2. For each seismic-restraint device, including **[seismic-restrained mounting,][pipe-riser resilient support,][snubber,][seismic restraint,][seismic-restraint accessory,][concrete anchor and insert,][and][restrained isolation roof-curb rail]** that is required by this Section or is indicated on Drawings, submit the following:
 - a. Seismic Restraint, Vibration Isolator, and Vibration Isolation Base Selection: Select and submit seismic restraints **[and]** vibration isolators [, **and vibration isolation bases**] complying with performance requirements, design criteria, and analysis data.
 - b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.
 - c. Post-Installed Concrete Anchors and Concrete Inserts: Include calculations showing anticipated seismic loads. Include certification that device is approved by an NRTL for

- reinforcement use.
- d. Seismic Design Calculations: Submit all input data and loading calculations.
- 3. For each wind-restraint device, including **[restraint - rigid],[restraint - cable],[restraint accessory],[concrete anchor],[and][concrete insert]** that is required by this Section or is indicated on Drawings, submit the following:
 - a. Wind Restraints: Select and submit wind restraints complying with performance requirements, design criteria, and analysis data.
 - b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated wind-resistant loads. Include certification that device is approved by an NRTL for reinforcement use.
 - c. Wind-Restraint Design Calculations: Submit all input data and loading calculations.
- 4. Seismic- and Wind-Restraint Detail Drawing:
 - a. Design Analysis: To support selection and arrangement of seismic **and wind** restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.
- 5. Product Listing, Preapproval, and Evaluation Documentation: By **[an evaluation service member of ICC-ES][UL][FM Approvals][OSHPD][an agency acceptable to authorities having jurisdiction]**, showing maximum ratings of restraint items and basis for approval (tests or calculations).
- 6. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
- 7. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation **and wind-** and seismic-restraint devices for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
- B. Qualification Data: For **[professional engineer][and][testing agency]**.
- C. Welding certificates.
- D. Air-Spring Isolator Performance Certification: Include natural frequency, load, and damping test data **performed by an independent agency**.
- E. Field quality-control reports.

1.6 REGULATORY AGENCY APPROVALS

- A. Delegated design submittals and Shop Drawings requiring approval by authorities having jurisdiction must be signed by qualified structural professional engineer responsible for their preparation. **[Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.][Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.]**

1.7 QUALIFICATIONS

- A. Professional Structural Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including design of seismic and wind restraints, equipment hangers and supports, and concrete foundations.

1.8 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For **[air-spring isolators][and][restrained-air-spring isolators]** to include in operation and maintenance manuals.

1.9 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage qualified professional structural engineer to prepare seismic- and wind-restraint calculations in accordance with criteria specified in Section 018123 "Facility Seismic and Wind Criteria."
- B. Seismic- and Wind-Restraint-Device Load Ratings: Devices are to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices are to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: **[ICC-ES product listing][UL product listing][FM Approvals][an evaluation service member of ICC-ES][an agency acceptable to authorities having jurisdiction]**.
- C. Consequential Damage: Provide additional seismic **and wind** restraints for suspended components or anchorage of floor-, roof-, or wall-mounted components so that failure of a non-essential or essential component will not cause failure of any other essential building component.
- D. Fire/Smoke Resistance: Seismic- and wind-restraint devices that are not constructed of ferrous metals are to have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by qualified testing laboratory in accordance with ASTM E84 or UL 723 and be labeled as such.

E. Component Supports:

1. Load ratings, features, and applications of reinforcement components are to be based on testing standards of qualified testing laboratory.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[Mason Industries, Inc.]**
 - h. **[NOVIA; a division of Carpenter & Paterson]**
 - i. **[Vibration Eliminator Co., Inc]**
 - j. **[Vibration Isolation]**
 - k. **[Vibration Management Corp.]**
 - l. **[VMC GROUP]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[Mason Industries, Inc.]**
 - h. **[NOVIA; a division of Carpenter & Paterson]**
 - i. **[Vibration Eliminator Co., Inc]**
 - j. **[Vibration Isolation]**
 - k. **[Vibration Management Corp.]**
 - l. **[VMC GROUP]**
 - m. **<Insert manufacturer's name>**
3. Source Limitations: Obtain elastomeric isolation pads from single manufacturer.
4. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
5. Size: Factory or field cut to match requirements of supported equipment.
6. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
7. Surface Pattern: Smooth, ribbed, or waffle pattern.
8. Infused nonwoven cotton or synthetic fibers.
9. Load-bearing metal plates adhered to pads.

10. Sandwich-Core Material: **[Resilient][and][elastomeric]<Insert compound>**.

- a. Surface Pattern: Smooth, ribbed, or waffle pattern.
- b. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[NOVIA; a division of Carpenter & Paterson]**
 - h. **[Vibration Eliminator Co., Inc]**
 - i. **[Vibration Isolation]**
 - j. **[Vibration Management Corp.]**
 - k. **[VMC GROUP]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[NOVIA; a division of Carpenter & Paterson]**
 - h. **[Vibration Eliminator Co., Inc]**
 - i. **[Vibration Isolation]**
 - j. **[Vibration Management Corp.]**
 - k. **[VMC GROUP]**
 - l. **<Insert manufacturer's name>**
3. Source Limitations: Obtain double-deflection, elastomeric isolation mounts from single manufacturer.
4. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded **[with threaded studs or bolts]**.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
5. Elastomeric Material: Molded, oil- and water- resistant neoprene rubber, silicone rubber, or other

elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[NOVIA; a division of Carpenter & Paterson]**
 - h. **[Vibration Eliminator Co., Inc]**
 - i. **[Vibration Isolation]**
 - j. **[Vibration Management Corp.]**
 - k. **[VMC GROUP]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[NOVIA; a division of Carpenter & Paterson]**
 - h. **[Vibration Eliminator Co., Inc]**
 - i. **[Vibration Isolation]**
 - j. **[Vibration Management Corp.]**
 - k. **[VMC GROUP]**
 - l. **<Insert manufacturer's name>**
3. Source Limitations: Obtain restrained elastomeric isolation mounts from single manufacturer.
4. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
3. Source Limitations: Obtain freestanding, laterally stable, open-spring isolators from single manufacturer.
 4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 8. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates limit floor load to **500 psig (3447 kPa)**.
 9. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 HOUSED-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Ace Mountings Co., Inc.]
- b. [CADDY; brand of nVent Electrical plc]
- c. [California Dynamics Corporation]
- d. [Isolation Technology, Inc]
- e. [Kinetics Noise Control, Inc]
- f. [Korfund]
- g. [Vibration Eliminator Co., Inc]
- h. [Vibration Isolation]
- i. [Vibration Management Corp.]
- j. [VMC GROUP]
- k. <Insert manufacturer's name>

- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Ace Mountings Co., Inc.]
- b. [CADDY; brand of nVent Electrical plc]
- c. [California Dynamics Corporation]
- d. [Isolation Technology, Inc]
- e. [Kinetics Noise Control, Inc]
- f. [Korfund]
- g. [Vibration Eliminator Co., Inc]
- h. [Vibration Isolation]
- i. [Vibration Management Corp.]
- j. [VMC GROUP]
- k. <Insert manufacturer's name>

- 3. Source Limitations: Obtain freestanding, laterally stable, open-spring isolators in two-part telescoping housing from single manufacturer.
- 4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
- 5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
- 6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- 7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- 8. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases limit floor load to **500 psig (3447 kPa)**.
 - b. Top housing with [attachment and leveling bolt][threaded mounting holes and internal leveling device][elastomeric pad].

2.7 RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the

following]:

- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
3. Source Limitations: Obtain restrained-spring isolators from single manufacturer.
4. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
- a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases limit floor load to **500 psig (3447 kPa)**.
 - b. Top plate with **[threaded mounting holes][elastomeric pad]**.
 - c. Internal leveling bolt that acts as blocking during installation.
5. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
6. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
7. Minimum Additional Travel: 50 percent of the required deflection at rated load.
8. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
9. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping

Housing :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[Vibration Eliminator Co., Inc]**
 - h. **[Vibration Isolation]**
 - i. **[Vibration Management Corp.]**
 - j. **[VMC GROUP]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[Vibration Eliminator Co., Inc]**
 - h. **[Vibration Isolation]**
 - i. **[Vibration Management Corp.]**
 - j. **[VMC GROUP]**
 - k. **<Insert manufacturer's name>**
3. Source Limitations: Obtain freestanding, open-spring isolators with vertical-limit stop restraints from single manufacturer.
4. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with **[adjustable][non-adjustable]** snubbers to limit vertical movement.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases limit floor load to **500 psig (3447 kPa)**.
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
5. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
6. Minimum Additional Travel: 50 percent of the required deflection at rated load.
7. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
8. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 PIPE-RISER RESILIENT SUPPORT

- A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-

Inch- (13-mm-) Thick Neoprene :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[California Dynamics Corporation]**
 - b. **[Kinetics Noise Control, Inc]**
 - c. **[Vibration Eliminator Co., Inc]**
 - d. **[Vibration Management Corp.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[California Dynamics Corporation]**
 - b. **[Kinetics Noise Control, Inc]**
 - c. **[Vibration Eliminator Co., Inc]**
 - d. **[Vibration Management Corp.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain resilient pipe-riser supports from single manufacturer.
4. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum **1/2-inch- (13-mm-)** thick neoprene.
5. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
6. Maximum Load Per Support: **500 psig (3447 kPa)** on isolation material providing equal isolation in all directions.

2.10 RESILIENT PIPE GUIDES

- A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-Inch- (13-mm-) Thick Neoprene :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[California Dynamics Corporation]**
 - b. **[Kinetics Noise Control, Inc]**
 - c. **[Vibration Eliminator Co., Inc]**
 - d. **[Vibration Management Corp.]**
 - e. **[VMC GROUP]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[California Dynamics Corporation]**
 - b. **[Kinetics Noise Control, Inc]**

- c. [Vibration Eliminator Co., Inc]
 - d. [Vibration Management Corp.]
 - e. [VMC GROUP]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain resilient pipe guides from single manufacturer.
 4. Description: Resilient pipe guide with telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum **1/2-inch- (13-mm-)** thick neoprene.
 5. Factory-Set Height Guide with Shear Pin: Shear pin to be removable and reinsertable to allow for selection of pipe movement. Guides to be capable of motion to meet location requirements.

2.11 AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [CADDY; brand of nVent Electrical plc]
 - b. [Firestone Industrial Products Company]
 - c. [Vibration Management Corp.]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert **manufacturer's name; product name or designation**> or comparable product by one of the following:
 - a. [CADDY; brand of nVent Electrical plc]
 - b. [Firestone Industrial Products Company]
 - c. [Vibration Management Corp.]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain air-spring isolators from single manufacturer.
4. Arrangement: **[Single][or][multiple]**.
5. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
6. Maximum Natural Frequency: 3 Hz.
7. Operating Pressure Range: **25 to 100 psig (172 to 690 kPa)**.
8. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
9. Automatic leveling valve.

2.12 RESTRAINED-AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows with Vertical-Limit Stop Restraint :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [CADDY; brand of nVent Electrical plc]
 - b. [Firestone Industrial Products Company]

- c. **[Vibration Management Corp.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[CADDY; brand of nVent Electrical plc]**
 - b. **[Firestone Industrial Products Company]**
 - c. **[Vibration Management Corp.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain restrained-air-spring isolators from single manufacturer.
4. Arrangement: **[Single][or][multiple]**.
5. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
- a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases limit floor load to **500 psig (3447 kPa)**.
 - b. Top plate with **[threaded mounting holes][elastomeric pad]**.
 - c. Internal leveling bolt that acts as blocking during installation.
6. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
7. Minimum Additional Travel: 50 percent of the required deflection at rated load.
8. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
9. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
10. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
11. Maximum Natural Frequency: **[3 Hz]<Insert frequency>**.
12. Operating Pressure Range: **25 to 100 psig (172 to 690 kPa)**.
13. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
14. Automatic leveling valve.

2.13 ELASTOMERIC HANGERS**A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods :**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Kinetics Noise Control, Inc]**
 - e. **[NOVIA; a division of Carpenter & Paterson]**
 - f. **[Vibration Eliminator Co., Inc]**
 - g. **[Vibration Isolation]**
 - h. **[Vibration Management Corp.]**
 - i. **[VMC GROUP]**
 - j. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Kinetics Noise Control, Inc]
 - e. [NOVIA; a division of Carpenter & Paterson]
 - f. [Vibration Eliminator Co., Inc]
 - g. [Vibration Isolation]
 - h. [Vibration Management Corp.]
 - i. [VMC GROUP]
 - j. **<Insert manufacturer's name>**
3. Source Limitations: Obtain elastomeric hangers from a single manufacturer.
4. Description: Elastomeric hanger mounted in a steel frame with upper and lower steel hanger rods.
5. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
6. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.14 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Kinetics Noise Control, Inc]
 - e. [NOVIA; a division of Carpenter & Paterson]
 - f. [Vibration Eliminator Co., Inc]
 - g. [Vibration Isolation]
 - h. [Vibration Management Corp.]
 - i. [VMC GROUP]
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Kinetics Noise Control, Inc]
 - e. [NOVIA; a division of Carpenter & Paterson]
 - f. [Vibration Eliminator Co., Inc]
 - g. [Vibration Isolation]

- h. [Vibration Management Corp.]
- i. [VMC GROUP]
- j. <Insert manufacturer's name>

- 3. Source Limitations: Obtain spring hangers from single manufacturer.
- 4. Description: Combination coil-spring and elastomeric-insert hanger.
- 5. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
- 6. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
- 7. Minimum Additional Travel: 50 percent of the required deflection at rated load.
- 8. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- 9. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- 10. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
- 11. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
- 12. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.15 SNUBBERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. [CADDY; brand of nVent Electrical plc]
 - 2. [Kinetics Noise Control, Inc]
 - 3. [Vibration Management Corp.]
 - 4. [VMC GROUP]
 - 5. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. [CADDY; brand of nVent Electrical plc]
 - 2. [Kinetics Noise Control, Inc]
 - 3. [Vibration Management Corp.]
 - 4. [VMC GROUP]
 - 5. <Insert manufacturer's name>
- C. Source Limitations: Obtain snubbers from single manufacturer.
- D. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 - 1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be seismically prequalified in accordance with ACI 355.2 testing and designated in accordance with **[ACI 318-08 Appendix D for 2009 IBC][ACI 318-11 Appendix D for 2012 IBC][ACI 318-14, Ch. 17 for 2015 or 2018 IBC]**.
 - 2. Preset Concrete Inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.
 - 3. Anchors in Masonry: Design in accordance with TMS 402.
 - 4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 - 5. Resilient Cushion: Maximum **1/4-inch (6-mm)** air gap, and minimum **1/4 inch (6 mm)** thick.

2.16 RESTRAINTS - RIGID TYPE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Atkore Unistrut]**
 2. **[CADDY; brand of nVent Electrical plc]**
 3. **[California Dynamics Corporation]**
 4. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 5. **[Hilti, Inc.]**
 6. **[Isolation Technology, Inc]**
 7. **[TOLCO Incorporated]**
 8. **[VMC GROUP]**
 9. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Atkore Unistrut]**
 2. **[CADDY; brand of nVent Electrical plc]**
 3. **[California Dynamics Corporation]**
 4. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 5. **[Hilti, Inc.]**
 6. **[Isolation Technology, Inc]**
 7. **[TOLCO Incorporated]**
 8. **[VMC GROUP]**
 9. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain rigid-type restraints from single manufacturer.
- D. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.17 RESTRAINTS - CABLE TYPE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[CADDY; brand of nVent Electrical plc]**
 2. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 3. **[Gripple Inc.]**
 4. **[Loos & Co. Inc.]**
 5. **[VMC GROUP]**
 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[CADDY; brand of nVent Electrical plc]**
 2. **[Cooper B-line; brand of Eaton, Electrical Sector]**

3. [Gripple Inc.]
4. [Loos & Co. Inc.]
5. [VMC GROUP]
6. <Insert manufacturer's name>

- C. Source Limitations: Obtain cable-type restraints from single manufacturer.
- D. Seismic- and Wind-Restraint Cables: **[ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel][ASTM A492 stainless steel]** cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.
- E. Restraint cable assembly with cable fittings must comply with ASCE/SEI 19. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.18 RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. [Atkore Unistrut]
2. [CADDY; brand of nVent Electrical plc]
3. [Cooper B-line; brand of Eaton, Electrical Sector]
4. [Hilti, Inc.]
5. [Loos & Co. Inc.]
6. [TOLCO Incorporated]
7. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [Atkore Unistrut]
2. [CADDY; brand of nVent Electrical plc]
3. [Cooper B-line; brand of Eaton, Electrical Sector]
4. [Hilti, Inc.]
5. [Loos & Co. Inc.]
6. [TOLCO Incorporated]
7. <Insert manufacturer's name>

- C. Source Limitations: Obtain restraint accessories from single manufacturer.
- D. Hanger-Rod Stiffener: **[Steel tube or steel slotted-support-system sleeve with internally bolted connections][Reinforcing steel angle clamped]** to hanger rod. Non-metallic stiffeners are unacceptable.
- E. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to **[rigid channel bracings][and][restraint cables]**.
- F. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.
- G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and

steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

- H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.19 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Atkore Unistrut]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - c. **[Hilti, Inc.]**
 - d. **[Powers Fasteners]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Atkore Unistrut]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - c. **[Hilti, Inc.]**
 - d. **[Powers Fasteners]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain mechanical anchor bolts from single manufacturer.
4. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Atkore Unistrut]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - c. **[Hilti, Inc.]**
 - d. **[Powers Fasteners]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Atkore Unistrut]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**

- c. [Hilti, Inc.]
- d. [Powers Fasteners]
- e. <Insert manufacturer's name>

- 3. Source Limitations: Obtain adhesive anchor bolts from single manufacturer.
- 4. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

- C. Provide post-installed concrete anchors that have been prequalified for use in wind-restraint applications. Post-installed concrete anchors must comply with all requirements of [ASCE/SEI 7-05, Ch. 13][ASCE/SEI 7-10, Ch. 13][ASCE/SEI 7-16, Ch. 13].

- 1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
- 2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

- D. Expansion-type anchor bolts are not permitted for equipment in excess of **10 hp (7.46 kW)** that is not vibration isolated.

- 1. Undercut expansion anchors are permitted.

2.20 CONCRETE INSERTS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1. [Atkore Unistrut]
- 2. [Cooper B-line; brand of Eaton, Electrical Sector]
- 3. [Hilti, Inc.]
- 4. [Powers Fasteners]
- 5. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1. [Atkore Unistrut]
- 2. [Cooper B-line; brand of Eaton, Electrical Sector]
- 3. [Hilti, Inc.]
- 4. [Powers Fasteners]
- 5. <Insert manufacturer's name>

- C. Source Limitations: Obtain concrete inserts from single manufacturer.

- D. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC466 testing.

- E. Comply with ANSI/MSS SP-58.

2.21 VIBRATION ISOLATION EQUIPMENT BASES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[CADDY; brand of nVent Electrical plc]**
 2. **[California Dynamics Corporation]**
 3. **[Kinetics Noise Control, Inc]**
 4. **[NOVIA; a division of Carpenter & Paterson]**
 5. **[Vibration Eliminator Co., Inc]**
 6. **[Vibration Isolation]**
 7. **[Vibration Management Corp.]**
 8. **[VMC GROUP]**
 9. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[CADDY; brand of nVent Electrical plc]**
 2. **[California Dynamics Corporation]**
 3. **[Kinetics Noise Control, Inc]**
 4. **[NOVIA; a division of Carpenter & Paterson]**
 5. **[Vibration Eliminator Co., Inc]**
 6. **[Vibration Isolation]**
 7. **[Vibration Management Corp.]**
 8. **[VMC GROUP]**
 9. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain vibration isolation equipment bases from single manufacturer.
- D. Steel Rails: Factory-fabricated, welded, structural-steel rails.
1. Design Requirements: Lowest possible mounting height with not less than **1-inch (25-mm)** clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails to have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- E. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.
1. Design Requirements: Lowest possible mounting height with not less than **1-inch (25-mm)** clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases to have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

- F. Concrete Inertia Base: **[Factory-fabricated][or][field-fabricated]**, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than **1-inch (25-mm)** clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases to have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.22 SEISMICALLY RESTRAINED ISOLATION ROOF-CURB RAILS

- A. Seismically Restrained Isolation Roof-Curb Rails:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[CADDY; brand of nVent Electrical plc]**
 - b. **[California Dynamics Corporation]**
 - c. **[Kinetics Noise Control, Inc]**
 - d. **[NOVIA; a division of Carpenter & Paterson]**
 - e. **[Thybar Corporation]**
 - f. **[Vibration Eliminator Co., Inc]**
 - g. **[Vibration Management Corp.]**
 - h. **[VMC GROUP]**
 - i. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CADDY; brand of nVent Electrical plc]**
 - b. **[California Dynamics Corporation]**
 - c. **[Kinetics Noise Control, Inc]**
 - d. **[NOVIA; a division of Carpenter & Paterson]**
 - e. **[Thybar Corporation]**
 - f. **[Vibration Eliminator Co., Inc]**
 - g. **[Vibration Management Corp.]**
 - h. **[VMC GROUP]**
 - i. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain restrained isolation roof-curb rails from single manufacturer.
 4. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic **[and wind]** forces.
 5. Upper Frame: To provide continuous support for equipment and to be captive to resiliently resist

- seismic[**and wind**] forces.
6. Lower Support Assembly: To be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. Lower support assembly to have a means for attaching to building structure and a wood nailer for attaching roof materials, and to be insulated with a minimum of **2 inches (50 mm)** of rigid, glass-fiber insulation on inside of assembly. Mount adjustable, restrained-spring isolators on elastomeric vibration isolation pads and provide access ports, for level adjustment, with removable waterproof covers at all isolator locations. Locate isolators so they are accessible for adjustment at any time during the life of the installation without interfering with integrity of roof.
 7. Snubber Bushings: All-directional, elastomeric snubber bushings at least **1/4 inch (6 mm)** thick.
 8. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic- [**and wind**]-restraint devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by [**an evaluation service member of ICC-ES**][**OSHPD**][**an agency acceptable to authorities having jurisdiction**].
- B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Assemblies: Where not specifically indicated otherwise, select sizes of components so strength is adequate to carry static[, **wind load**,] and seismic loads within specified loading limits.

3.3 INSTALLATION OF VIBRATION CONTROLS AND SEISMIC RESTRAINTS FOR HVAC PIPING AND EQUIPMENT

- A. Provide seismic-[**and wind**]-restraint devices and vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Devices Schedules, where indicated on Drawings, or where Specifications indicate they are to be installed on specific equipment and systems.
- B. Provide seismic-restraint [**and wind-restraint**] devices for systems and equipment where indicated in Equipment Schedules or Seismic-Restraint Devices Schedules, where indicated on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

- C. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- D. Installation of vibration isolators[, **wind restraints**,] must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- E. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- F. Equipment Restraints:
 - 1. Install snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds **0.125 inch (3.2 mm)**.
 - 3. Install seismic-restraint[, **and wind-restraint**] devices using methods approved by **[an evaluation service member of ICC-ES][OSHPD][an agency acceptable to authorities having jurisdiction]** that provides required submittals for component.
- G. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of **[40 feet (12 m)]<Insert dimension>** o.c., and longitudinal supports a maximum of **[80 feet (24 m)]<Insert dimension>** o.c.
 - 3. Brace a change of direction longer than **12 feet (3.7 m)**.
- H. Ductwork Restraints:
 - 1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with **[SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."][SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems - OSHPD Edition."][ASCE/SEI 7.][See Section 233113 "Metal Ducts" for Seismic Hazard Level (SHL).][See Section 233113 "Metal Ducts" for "Connection Level" performance requirement for OSHPD jurisdictions.]<Insert requirement.>**
 - 2. Space lateral supports a maximum of **[40 feet (12 m)]<Insert dimension>** o.c., and longitudinal supports a maximum of **[80 feet (24 m)]<Insert dimension>** o.c.
 - 3. Brace a change of direction longer than **12 feet (3.7 m)**.
 - 4. Select seismic-restraint devices with capacities adequate to carry static and seismic loads.
 - 5. Install cable restraints on ducts that are suspended with vibration isolators.
- I. Install seismic-[**and wind**]restraint cables so they do not bend across edges of adjacent equipment or building structure.
- J. Install seismic-[**and wind**]restraint devices using methods approved by **[an evaluation service member of ICC-ES][OSHPD][an agency acceptable to authorities having jurisdiction]** that provides required submittals for component.
- K. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- L. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

- M. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- N. Post-Installed Concrete Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Mechanical Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors to be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 INSTALLATION OF AIR-SPRING ISOLATORS

- A. Independent Isolator Installation:
 - 1. Install tank valve into each air isolator.
 - 2. Inflate each isolator to **[height][and][pressure]** specified on Drawings.
- B. Pressure-Regulated Isolator Installation:
 - 1. Coordinate the constant pressure-regulated air supply to air springs with requirements for piping and connections specified in Section 221513 "General-Service Compressed-Air Piping."
 - 2. Connect all pressure regulators to a single dry, filtered **[facility][constant]** air supply.
 - 3. Inflate isolators to **[height][and][or][pressure]** specified on Drawings.

3.5 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Provide flexible connections in piping systems where they cross structural seismic joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for piping flexible connections.

3.6 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES

- A. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- B. Coordinate dimensions of steel equipment rails and bases, concrete inertia bases, and restrained isolation roof-curb rails with requirements of isolated equipment specified in this and other Sections. Where dimensions of these bases are indicated on Drawings, dimensions may require adjustment to accommodate actual isolated equipment.

3.7 ADJUSTING

- A. Adjust isolators after system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections:
 - 1. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
 - 2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 3. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 - 4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - 5. Test no fewer than **[four]<Insert number>** of each type and size of installed anchors and fasteners selected by Architect.
 - 6. Test to 90 percent of rated proof load of device.
 - 7. Measure isolator restraint clearance.
 - 8. Measure isolator deflection.
 - 9. Verify snubber minimum clearances.
 - 10. Test and adjust restrained-air-spring isolator controls and safeties.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Units will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION 23 05 48 00

SECTION 23 05 48 00A - VIBRATION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Mechanical vibration switches.
2. Electronic vibration switches.
3. Combination vibration switches and transmitters.
4. Vibration transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 DEFINITIONS

- A. RMS:** Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include operating characteristics, electrical characteristics, and furnished accessories indicating default control signal with loss of power, calibration data specific to each unique application, and electrical power requirements.
3. Include product description with complete technical data, performance curves, and product specification sheets.
4. Include installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and[**mounting**] details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring and cable.



1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation details, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades:
 - 1. Product installation location shown in relationship to room, conduit, duct, pipe, and equipment.
 - 2. Sizes and locations of wall access panels for instruments installed behind walls.
 - 3. Sizes and locations of ceiling access panels for instruments installed in inaccessible ceilings.
- B. Product Certificates: For each product requiring a certificate.
- C. Product Test Reports: For each vibration instrument, for tests performed by **[manufacturer and witnessed by a qualified testing agency][a qualified testing agency]**.
- D. Source quality-control reports.
- E. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: To include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 MECHANICAL VIBRATION SWITCHES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[FW Murphy Production Controls]**
 - 2. **[IMI Sensors; a division of PCB Piezotronics]**
 - 3. **[Metrix Instrument Co.]**
 - 4. **[Robertshaw]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[FW Murphy Production Controls]**
 - 2. **[IMI Sensors; a division of PCB Piezotronics]**
 - 3. **[Metrix Instrument Co.]**
 - 4. **[Robertshaw]**
 - 5. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain all mechanical vibration switches from a single manufacturer.
- D. Description: Inertia-sensitive armature mechanism trips on high vibration and operates snap action switch.

- E. Hazardous Environment Certification: Listed and labeled as defined in NFPA 70, by a NRTL, and marked for hazardous environments Class I, Group D; Class II, Groups E, F, and G; and Class III.
- F. Performance:
 - 1. Frequency Range: Zero to **[60][100][300]<Insert value>** Hz.
 - 2. Vibration Range: Zero to **[2][5][7][16]<Insert value>** g.
 - 3. Temperature Limits: **[Minus 40 to 140 deg F (Minus 40 to 60 deg C)][Minus 40 to 158 deg F (Minus 40 to 70 deg C)][Minus 40 to 200 deg F (Minus 40 to 93 deg C)]<Insert temperature range>**.
- G. Switch Type: Electromechanical **[SPDT][or][DPDT]** snap switch.
 - 1. Electrical Rating: **[5][7][15]<Insert value>** A at **[120][or][480]** V ac.
- H. Start Delay: Time delay during equipment startup to prevent switch from nuisance tripping.
- I. Operator Interface:
 - 1. Vibration Set-Point Adjustment: Zero to 100 percent of range.
 - 2. Reset: Local push-button reset on exterior of switch **[and reset coil for remote reset by operator through a DDC system interface]**.
- J. Enclosure:
 - 1. Material: Cast aluminum.
 - 2. Rating: NEMA 250, **[Type 4][or][Type 4X]**.
 - 3. Electrical Connection: Screw terminals.
 - 4. Conduit Connection: **3/4-inch (21-mm)** trade size.

2.2 ELECTRONIC VIBRATION SWITCHES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[IMI Sensors; a division of PCB Piezotronics]**
 - 2. **[Metrix Instrument Co.]**
 - 3. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[IMI Sensors; a division of PCB Piezotronics]**
 - 2. **[Metrix Instrument Co.]**
 - 3. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain all electronic vibration switches from a single manufacturer.
- D. Description: Electronic switch with accelerometer-based velocity response.
- E. Hazardous Environment Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Group D; Class II, Groups E, F, and G; and Class III.

F. Performance:

1. Frequency Range: [3 to 500][7 to 1000]<Insert value> Hz.
2. Vibration Range: [Zero to 1.0 inch (25 mm)]<Insert value> per second.
3. Temperature Limits: [Minus 40 to 212 deg F (Minus 20 to 100 deg C)][Minus 40 to 185 deg F (Minus 20 to 85 deg C)][Minus 4 to 167 deg F (Minus 20 to 75 deg C)]<Insert temperature range>.

G. Functional Characteristics:

1. Trip Logic: Field selectable, normally open/normally closed, latching/nonlatching, automatic/manual reset.
 - a. Solid-State Relay: [500]<Insert value> mA at 24 to 240 V ac or dc; normally open leakage up to [1]<Insert value> mA.
 - b. Triac: [5]<Insert value> A inductive, [60]<Insert value> A surge for one cycle; normally open leakage is [10]<Insert value> mA.
2. Start Trip Timer: [30][45][60]<Insert value> seconds.
3. Monitor Trip Delay: [3]<Insert value> seconds.

H. Operator Interface:

1. Vibration Set-Point Adjustment: Tamperproof graduated dial or software programmable, or configurable through a switch USB connection to personal computer.

I. Instrument Display:

1. Trip Indicator: Flashing LED.
2. LCD Display: Numerical display of vibration level.

J. Enclosure:

1. Material: Cast aluminum or stainless steel.
2. Screw-on cover.
3. Rating: NEMA 250, Type 4.
4. Electrical Connection: Screw terminal block or three-wires, [40 inches (1000 mm)][72 inches (1800 mm)][120 inches (3000 mm)]<Insert length> long.
5. Conduit Connection: 1/2-inch (13-mm) trade size or larger. Provide sealed entry for instruments with wire connections.
6. Flange mounting adapter, as applicable.

2.3 COMBINATION VIBRATION SWITCHES AND TRANSMITTERS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [IMI Sensors; a division of PCB Piezotronics]
2. [Metrix Instrument Co.]
3. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's

name; product name or designation> or comparable product by one of the following:

1. **[IMI Sensors; a division of PCB Piezotronics]**
 2. **[Metrix Instrument Co.]**
 3. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain all combination vibration switches and transmitters from a single manufacturer.
- D. Description: Field-configurable, electronic combination switches and transmitters.
- E. Hazardous Environment Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Group D; Class II, Groups E, F, and G; and Class III.
- F. Performance:
1. Frequency Range: **[2 to 1000]<Insert value>** Hz.
 2. Vibration Range: **[0 to 1.5 inches (0 to 38 mm)][0 to 3 inches (0 to 75 mm)][0.10 to 1.5 inches (3 to 38 mm)][0.20 to 3 inches (6 to 75 mm)]<Insert value>** per second.
 3. Accuracy: Within **[10]<Insert value>** percent of setpoint.
 4. Repeatability: Within **[2]<Insert value>** percent of setpoint.
 5. Ambient Temperature Limits: **[Minus 22 to 158 deg F (Minus 30 to 70 deg C)][Minus 20 to 140 deg F (Minus 29 to 60 deg C)]<Insert temperature range>**.
 6. Ambient Relative Humidity: **[0 to 100][1 to 100]<Insert value>**; noncondensing.
- G. Analog Output Current Signal:
1. Two-wire, 4 to 20 mA dc current source.
 2. Signal capable of operating into **[450]<Insert value>**-ohm load.
- H. Digital Output Signal: **[Single][or][dual][Single or dual, as required by application,]** alarm relay(s).
1. Electromechanical (SPDT) Relay: **[5][10]<Insert value>** A at **[120][240]<Insert value>** V ac.
 2. Solid-State Relay: **[5][10]<Insert value>** A at **[120][240]<Insert value>** V ac.
 3. Triac: **[5][10]<Insert value>** A at **[120][240]<Insert value>** V ac.
- I. Display: Separate LED for each alarm set point. LED lights upon exceeding setpoint.
- J. Operator Interface:
1. Set-Point Adjustment: Internally accessible adjustable dial(s) or pushbutton(s).
 2. Alarm Reset: **[Alarm condition automatically clears when vibration levels fall below switch set point.][Alarm condition cleared by operator through manual reset button found on the instrument.][Alarm condition cleared remotely by operator through DDC system interface.]**
 3. Adjustable Time Delays: Intended to prevent false trips during equipment startup and short-term vibration spikes.
- K. Accelerometer: **[Integral][or][external]**.
- L. Enclosure:
1. Material: Cast aluminum.
 2. Screw-on cover.
 3. Rating: NEMA 250, **[Type 4X][Type 7][Type 9]**.

4. Electrical Connection: Screw terminals.
5. Conduit Connection: 1/2-inch (13-mm) or 3/4-inch (21-mm) trade size.

2.4 VIBRATION TRANSMITTERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Dwyer Instruments, Inc]**
2. **[IMI Sensors; a division of PCB Piezotronics]**
3. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Dwyer Instruments, Inc]**
2. **[IMI Sensors; a division of PCB Piezotronics]**
3. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain all vibration transmitters from a single manufacturer.

- D. Description: Loop-powered vibration transmitters with current output.

- E. Performance:

1. Frequency Range: **[3 to 1000][10 to 1000]<Insert value>** Hz.
2. Vibration Range: **[Zero to 0.5 inch (13 mm)][Zero to 1.0 inch (25 mm)][Zero to 2.0 inch (50 mm)]<Insert value>** per second.
3. Accuracy: Within **[1][3]<Insert value>** percent of measured value.
4. Ambient Temperature Limits: **[Minus 40 to 185 deg F (Minus 40 to 85 deg C)][Minus 22 to 221 deg F (Minus 30 to 105 deg C)]<Insert temperature range>**.

- F. Analog Output Current Signal:

1. Two-wire, 4 to 20 mA dc current source.
2. Signal capable of operating into **[500][1000]<Insert value>**-ohm load.

- G. Enclosure Construction:

1. Material: Type 316 stainless steel.
2. Rating: NEMA 250, **[Type 6][or][Type 6P]**.
3. Electrical Connection: Screw-on cable connector.

2.5 SOURCE QUALITY CONTROL

- A. Factory Tests and Inspections: Test and inspect assembled vibration instruments, as indicated by instrument requirements. Affix standards organization's certification and label.
- B. Prepare test and inspection reports as applicable.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 VIBRATION INSTRUMENT APPLICATIONS

- A. Mechanical Vibration Switches: **<Insert application>**.
- B. Electronic Vibration Switches: **<Insert application>**.
- C. Combination Vibration Switches and Transmitters: **<Insert application>**.
- D. Vibration Transmitters: **<Insert application>**.

3.3 INSTALLATION

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- C. Properly support instrument wiring and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.
- D. Fastening Hardware:
 - 1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- F. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they are subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments.
 - 3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 - 4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of **[Type 316L**

stainless steel]<Insert material>.

3.4 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification.

3.7 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.8 CHECKOUT PROCEDURES

- A. Check installed products before continuity tests and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation with respect to location, elevation, orientation, or other applicable considerations that impact performance.
- D. Verify that wiring is correct and secure.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

- 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
- 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
- 3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
- 4. Equipment and procedures used for calibration are to comply with instrument manufacturer's written instructions.
- 5. Provide diagnostic and test equipment for calibration and adjustment.
- 6. Field instruments and equipment used to test and calibrate installed instruments are to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent is to be checked by an instrument with an accuracy of 0.5 percent.
- 7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
- 8. If, after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
- 9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11 in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

- 1. Check analog voltage signals using a voltage meter at zero, 50, and 100 percent of range.
- 2. Check analog current signals using a current meter at zero, 50, and 100 percent of range.

C. Digital Signals:

- 1. Check digital signals using a jumper wire.
- 2. Check digital signals using an ohmmeter to test for contact.

D. Switches: Calibrate switches to make or break contact at set points indicated.

3.10 ADJUSTING

- A. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.



3.11 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes **[three][six][nine][12]** months' full maintenance by **[skilled employees of systems and equipment Installer][manufacturer's authorized service representative]**. Include **[monthly][quarterly][semiannual][annual]** preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

3.12 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain speed instruments.
- B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 05 48 00A



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 05 48 00	23 05 00 00a	Coatings for HVAC



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 05 48 13 - VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient support.
9. Resilient pipe guides.
10. Air-spring isolators.
11. Restrained-air-spring isolators.
12. Elastomeric hangers.
13. Spring hangers.
14. Snubbers.
15. Restraints - rigid type.
16. Restraints - cable type.
17. Restraint accessories.
18. Post-installed concrete anchors.
19. Concrete inserts.
20. Vibration isolation equipment bases.
21. Restrained isolation roof-curb rails.

B. Related Requirements:

1. Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
2. Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment" for devices for plumbing equipment and systems.

1.2 DEFINITIONS

- A.** IBC: International Building Code.
- B.** OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Include load rating for each wind-force-restraint fitting and assembly.

3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device **[and wind-force-restraint]** component.
4. Annotate to indicate application of each product submitted and compliance with requirements.
5. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal:

1. For each wind-load protection device that is required by this Section or is indicated on Drawings, submit the following:
 - a. Vibration Isolator and Wind-Load-Restraint Selection: Select vibration isolators, wind-load restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.
 - b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.
 - c. Concrete Anchors and Inserts: Include calculations showing anticipated wind loads.
 - d. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.
 - e. Qualified Professional Engineer: All designated-design submittals for wind-restraint calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.
2. Wind-Restraint Detail Drawing:
 - a. Design Analysis: To support selection and arrangement of wind restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during wind events. Indicate association with vibration isolation devices.
 - c. Coordinate vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.
3. All delegated-design submittals for wind-restraint detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.
4. Product Listing, Preapproval, and Evaluation Documentation: By **[an evaluation service member of ICC-ES][UL][FM Approvals][OSHPD][an agency acceptable to authorities having jurisdiction]**, showing maximum ratings of restraint items and basis for approval (tests or calculations).
5. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
6. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection

changes. Include certification that riser system was examined for excessive stress and that none exists.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints.
- B. Qualification Data: For testing agency.
- C. Welding certificates.
- D. Air-Spring Mounting System Performance Certification: Include natural frequency, load, and damping test data[**performed by an independent agency**].
- E. Field quality-control reports.
- F. Wind-Force Performance Certification: Provide special certification for HVAC components subject to high wind exposure and impact damage and designated on Drawings or in the Specifications to require wind-force performance certification.
 - 1. Provide equipment manufacturer's written certification for each designated HVAC device, stating that it will remain in place and operable following the design wind event and comply with all requirements of authorities having jurisdiction.
 - 2. Provide manufacturer's written certification for each designated louver, damper, or similar device, stating that it will remain in place and protect opening from penetration of windborne debris and comply with all requirements of authorities having jurisdiction.
 - 3. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.
 - 4. The following HVAC systems and components require special certification for high wind performance. Written special certification of resistance to the effects of high wind force and impact damage must be provided by manufacturer:
 - a. **<Insert list>**.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For **[air-spring mounts][and][restrained-air-spring mounts]** to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7 and be acceptable to authorities having jurisdiction.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Wind-Load-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to



the public. Provide third-party listing by one or more of the following: **[ICC-ES product listing][UL product listing][FM Approvals][an evaluation service member of ICC-ES][an agency acceptable to authorities having jurisdiction]**.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design system.
 - 1. Wind-Load Performance: Equipment shall withstand the effects of high wind events determined in accordance with **[ASCE/SEI 7-05][ASCE/SEI 7-10][ASCE/SEI 7-16]<Insert requirement>**.
- B. Wind-Load Design Calculations:
 - 1. Perform calculations to obtain force information necessary to properly select wind-load-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in **[ASCE/SEI 7-05][ASCE/SEI 7-10][ASCE/SEI 7-16]<Insert ASCE/SEI 7 edition or other wind-force calculation method required by authorities having jurisdiction>**. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to in this subparagraph is intended as referenced throughout the Section Text unless otherwise noted.
 - a. Factors indicated below that are specific to individual pieces of equipment must be obtained by Contractor and must be included in individual component submittal packages.
 - b. Coordinate design wind-load calculations with vibration isolation requirements. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.
 - 2. Design wind pressure "p" for external sidewall-mounted equipment such as louvers is to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-16, Ch. 30. Perform calculations in accordance with one of the following, as appropriate:
 - a. PART 1: Low-Rise Buildings.
 - b. PART 2: Low-Rise Buildings (Simplified).
 - c. PART 3: Buildings with "h" less than **60 feet (18.3 m)**.
 - d. PART 4: Buildings with "h" greater than **60 feet (18.3 m)** and less than **160 feet (48.8 m)**.
 - e. PART 5: Open Buildings.
 - 3. Design wind pressure "p" for rooftop equipment is to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-16, Ch. 30, PART 6: Building Appurtenances and Rooftop Structures and Equipment.
 - a. Risk Category: **[I][II][III][IV][V]**.
 - b. h = Mean Roof Height: **<Insert value>**.
 - c. V = Basic Wind Speed: **<Insert value>**.
 - d. Kd = Wind Directionality Factor: **<Insert factor>**.
 - e. Exposure Category: **[B][C][D]**.
 - f. Kzt = Topographic Factor: **<Insert factor>**.
 - g. Ke = Ground Elevation Factor: **<Insert factor>**.
 - h. Kz = Velocity Pressure Exposure Coefficient (Evaluated at Height z): **<Insert coefficient>**.
 - i. Kh = Velocity Pressure Exposure Coefficient (Evaluated at Height h): **<Insert coefficient>**.

- j. qz = Velocity Pressure: Value calculated by delegated wind-load design Contractor using methods detailed in ASCE/SEI 7-16 Section 26.10.1 or other source approved by authorities having jurisdiction.
 - k. qh = Velocity Pressure: Value calculated by delegated wind-load design Contractor using methods detailed in ASCE/SEI 7-16 Section 26.10.1 or other source approved by authorities having jurisdiction.
 - l. G = Gust-Effect Factor: **[0.85]<Insert factor>**.
 - m. Enclosure Classification: **<Insert classification>**.
 - n. GCpi = Internal Pressure Coefficient: **<Insert coefficient>**.
4. Design wind pressure "p" for external sidewall-mounted equipment such as louvers are to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-10, Ch. 30. Perform calculations in accordance with one of the following, as appropriate:
 - a. PART 1: Low-Rise Buildings.
 - b. PART 2: Low-Rise Buildings (Simplified).
 - c. PART 3: Buildings with "h" greater than **60 feet (18.3 m)**.
 - d. PART 4: Buildings with "h" less than **160 feet (48.8 m)**.
 - e. PART 5: Open Buildings.
5. Design wind pressure "p" for rooftop equipment is to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-10, Ch. 30, PART 6: Building Appurtenances and Rooftop Structures and Equipment.
 - a. Risk Category: **[I][II][III][IV][V]**.
 - b. h = Mean roof height: **<Insert value>**.
 - c. V = Basic Wind Speed: **<Insert value>**.
 - d. Kd = Wind Directionality Factor: **<Insert factor>**.
 - e. Exposure Category: **[B][C][D]**.
 - f. Kzt = Topographic Factor: **<Insert factor>**.
 - g. Kz = Velocity Pressure Exposure Coefficient (Evaluated at Height z): **<Insert coefficient>**.
 - h. Kh = Velocity Pressure Exposure Coefficient (Evaluated at Height h): **<Insert coefficient>**.
 - i. qz = Velocity Pressure at Height z: Value calculated by delegated wind-load design Contractor using methods detailed in ASCE/SEI 7-10 Section 26.10.1 or other source approved by authorities having jurisdiction.
 - j. qh = Velocity Pressure at Height h: Value calculated by delegated wind-load design Contractor using methods detailed in ASCE/SEI 7-10 Section 26.10.1 or other source approved by authorities having jurisdiction.
 - k. G = Gust-Effect Factor: **[0.85]<Insert factor>**.
 - l. Enclosure Classification: **<Insert classification>**.
 - m. GCpi = Internal Pressure Coefficient: **<Insert coefficient>**.
6. Design wind force "F" for rooftop equipment and external sidewall-mounted equipment such as louvers is to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-05, Ch. 6.
 - a. I = Importance Factor: **<Insert factor>**.
 - b. h = Mean Roof Height: **<Insert value>**.
 - c. V = Basic Wind Speed: **<Insert value>**.
 - d. Kd = Wind Directionality Factor: **<Insert factor>**.
 - e. Exposure Category: **[B][C][D]**.
 - f. Kzt = Topographic Factor: **<Insert factor>**.
 - g. Kz = Velocity Pressure Exposure Coefficient (Evaluated at Height z): **<Insert coefficient>**.
 - h. Kh = Velocity Pressure Exposure Coefficient (Evaluated at Height h): **<Insert coefficient>**.
 - i. qz = Velocity Pressure at Height z: Value calculated by delegated wind-load design Contractor using methods detailed in ASCE/SEI 7-05 Section 6.5.10 or other source

- j. approved by authorities having jurisdiction.
qh = Velocity Pressure at Roof Height h: Value calculated by delegated wind-load design Contractor using methods detailed in ASCE/SEI 7-05 Section 6.5.10 or other source approved by authorities having jurisdiction.
- k. G = Gust-Effect Factor: **[0.85]<Insert factor>**.
- l. GC_{pi} = Internal Pressure Coefficient: **<Insert coefficient>**.
- m. GC_p = External Pressure Coefficient: **<Insert coefficient>**.
- n. Cf = Force Coefficient: Value determined by delegated wind-load design Contractor from ASCE/SEI 7-05, Figures 6-21 through 6-23 or other source approved by authorities having jurisdiction.
- o. Af = Projected Area Normal to the Wind: Except where "Cf" is specified for the actual surface area. Value determined by delegated wind-load design Contractor from equipment submittal or manufacturer.

- C. Consequential Damage: Provide additional restraints for suspended HVAC components or anchorage of floor-, roof-, or wall-mounted HVAC components as indicated in **[ASCE/SEI 7-05][ASCE/SEI 7-10][ASCE/SEI 7-16]** so that failure of a non-essential or essential HVAC component will not cause the failure of any other essential architectural, mechanical, or electrical building component.
- D. Fire/Smoke Resistance: All components that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.
- E. Component Supports:
 - 1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.

2.2 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads: .
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[Mason Industries, Inc.]**
 - h. **[NOVIA; a division of Carpenter & Paterson]**
 - i. **[Vibration Eliminator Co., Inc]**
 - j. **[Vibration Isolation]**
 - k. **[Vibration Management Corp.]**
 - l. **[VMC GROUP]**
 - m. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
3. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
 4. Size: Factory or field cut to match requirements of supported equipment.
 5. Minimum deflection as indicated on Drawings.
 6. Pad Material: Oil- and water-resistant rubber.
 7. Infused nonwoven cotton or synthetic fibers.
 8. Load-bearing metal plates adhered to pads.
 9. Sandwich-Core Material: [Resilient][and][elastomeric]<Insert compound>.
 - a. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Elastomeric Isolation Mounts: .

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]

- d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
3. Mounting Plates:
- a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded[**with threaded studs or bolts**].
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
4. Minimum deflection as indicated on Drawings.
5. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]

- g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
3. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
- a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.
4. Minimum deflection as indicated on Drawings.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]

- l. **[VMC GROUP]**
- m. **<Insert manufacturer's name>**
- 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
- 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
- 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- 7. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to **500 psi (3447 kPa)**.
- 8. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- 9. Minimum deflection as indicated on Drawings.

2.6 HOUSED-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing: .
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[Mason Industries, Inc.]**
 - h. **[Vibration Eliminator Co., Inc]**
 - i. **[Vibration Isolation]**
 - j. **[Vibration Management Corp.]**
 - k. **[VMC GROUP]**
 - l. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[Mason Industries, Inc.]**
 - h. **[Vibration Eliminator Co., Inc]**
 - i. **[Vibration Isolation]**
 - j. **[Vibration Management Corp.]**
 - k. **[VMC GROUP]**
 - l. **<Insert manufacturer's name>**

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Minimum deflection as indicated on Drawings.
8. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to **500 psi (3447 kPa)**.
 - b. Top housing with **[attachment and leveling bolt][threaded mounting holes and internal leveling device][elastomeric pad]**.

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[Mason Industries, Inc.]**
 - h. **[NOVIA; a division of Carpenter & Paterson]**
 - i. **[Vibration Eliminator Co., Inc]**
 - j. **[Vibration Isolation]**
 - k. **[Vibration Management Corp.]**
 - l. **[VMC GROUP]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[Mason Industries, Inc.]**
 - h. **[NOVIA; a division of Carpenter & Paterson]**
 - i. **[Vibration Eliminator Co., Inc]**
 - j. **[Vibration Isolation]**
 - k. **[Vibration Management Corp.]**
 - l. **[VMC GROUP]**
 - m. **<Insert manufacturer's name>**

3. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to **500 psi (3447 kPa)**.
 - b. Top plate with **[threaded mounting holes][elastomeric pad]**.
 - c. Internal leveling bolt that acts as blocking during installation.
4. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
5. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
6. Minimum Additional Travel: 50 percent of the required deflection at rated load.
7. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
8. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
9. Minimum deflection as indicated on Drawings.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing: .
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[Mason Industries, Inc.]**
 - h. **[Vibration Eliminator Co., Inc]**
 - i. **[Vibration Isolation]**
 - j. **[Vibration Management Corp.]**
 - k. **[VMC GROUP]**
 - l. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Isolation Technology, Inc]**
 - e. **[Kinetics Noise Control, Inc]**
 - f. **[Korfund]**
 - g. **[Mason Industries, Inc.]**
 - h. **[Vibration Eliminator Co., Inc]**
 - i. **[Vibration Isolation]**
 - j. **[Vibration Management Corp.]**

- k. **[VMC GROUP]**
 - l. **<Insert manufacturer's name>**
3. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with **[adjustable][non-adjustable]** snubbers to limit vertical movement.
- a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to **500 psi (3447 kPa)**.
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Minimum deflection as indicated on Drawings.

2.9 PIPE-RISER RESILIENT SUPPORT

- A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum **1/2-inch- (13-mm-)** Thick Neoprene: .
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[California Dynamics Corporation]**
 - b. **[Kinetics Noise Control, Inc]**
 - c. **[Mason Industries, Inc.]**
 - d. **[Vibration Eliminator Co., Inc]**
 - e. **[Vibration Management Corp.]**
 - f. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[California Dynamics Corporation]**
 - b. **[Kinetics Noise Control, Inc]**
 - c. **[Mason Industries, Inc.]**
 - d. **[Vibration Eliminator Co., Inc]**
 - e. **[Vibration Management Corp.]**
 - f. **<Insert manufacturer's name>**
 - 3. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 - 4. Maximum Load Per Support: **500 psi (3447 kPa)** on isolation material providing equal isolation in all directions.
 - 5. Minimum deflection as indicated on Drawings.

2.10 RESILIENT PIPE GUIDES

- A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch- (13-mm-) Thick Neoprene: .
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[California Dynamics Corporation]**
 - b. **[Kinetics Noise Control, Inc]**
 - c. **[Mason Industries, Inc.]**
 - d. **[Vibration Eliminator Co., Inc]**
 - e. **[Vibration Management Corp.]**
 - f. **[VMC GROUP]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[California Dynamics Corporation]**
 - b. **[Kinetics Noise Control, Inc]**
 - c. **[Mason Industries, Inc.]**
 - d. **[Vibration Eliminator Co., Inc]**
 - e. **[Vibration Management Corp.]**
 - f. **[VMC GROUP]**
 - g. **<Insert manufacturer's name>**
 3. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 AIR-SPRING ISOLATORS

- A. Freestanding, Single or Multiple, Compressed-Air Bellows: .
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[CADDY; brand of nVent Electrical plc]**
 - b. **[Firestone Industrial Products Company]**
 - c. **[Mason Industries, Inc.]**
 - d. **[Vibration Management Corp.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CADDY; brand of nVent Electrical plc]**
 - b. **[Firestone Industrial Products Company]**

- c. **[Mason Industries, Inc.]**
 - d. **[Vibration Management Corp.]**
 - e. **<Insert manufacturer's name>**
- 3. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
 - 4. Maximum Natural Frequency: 3 Hz.
 - 5. Operating Pressure Range: **25 to 100 psi (172 to 690 kPa)**.
 - 6. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
 - 7. Minimum deflection as indicated on Drawings.
 - 8. Automatic leveling valve.

2.12 RESTRAINED-AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows with Vertical-Limit Stop Restraint: .

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[CADDY; brand of nVent Electrical plc]**
 - b. **[Firestone Industrial Products Company]**
 - c. **[Mason Industries, Inc.]**
 - d. **[Vibration Management Corp.]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CADDY; brand of nVent Electrical plc]**
 - b. **[Firestone Industrial Products Company]**
 - c. **[Mason Industries, Inc.]**
 - d. **[Vibration Management Corp.]**
 - e. **<Insert manufacturer's name>**
- 3. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to **500 psi (3447 kPa)**.
 - b. Top plate with **[threaded mounting holes][elastomeric pad]**.
 - c. Internal leveling bolt that acts as blocking during installation.
- 4. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
- 5. Minimum deflection as indicated on Drawings.
- 6. Minimum Additional Travel: 50 percent of the required deflection at rated load.
- 7. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- 8. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- 9. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
- 10. Maximum Natural Frequency: 3 Hz.
- 11. Operating Pressure Range: **25 to 100 psi (172 to 690 kPa)**.

12. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
13. Automatic leveling valve.

2.13 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Kinetics Noise Control, Inc]**
 - e. **[Mason Industries, Inc.]**
 - f. **[NOVIA; a division of Carpenter & Paterson]**
 - g. **[Vibration Eliminator Co., Inc]**
 - h. **[Vibration Isolation]**
 - i. **[Vibration Management Corp.]**
 - j. **[VMC GROUP]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[California Dynamics Corporation]**
 - d. **[Kinetics Noise Control, Inc]**
 - e. **[Mason Industries, Inc.]**
 - f. **[NOVIA; a division of Carpenter & Paterson]**
 - g. **[Vibration Eliminator Co., Inc]**
 - h. **[Vibration Isolation]**
 - i. **[Vibration Management Corp.]**
 - j. **[VMC GROUP]**
 - k. **<Insert manufacturer's name>**
3. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
4. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.
5. Minimum deflection as indicated on Drawings.

2.14 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression: .

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Kinetics Noise Control, Inc]
 - e. [Mason Industries, Inc.]
 - f. [NOVIA; a division of Carpenter & Paterson]
 - g. [Vibration Eliminator Co., Inc]
 - h. [Vibration Isolation]
 - i. [Vibration Management Corp.]
 - j. [VMC GROUP]
 - k. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Kinetics Noise Control, Inc]
 - e. [Mason Industries, Inc.]
 - f. [NOVIA; a division of Carpenter & Paterson]
 - g. [Vibration Eliminator Co., Inc]
 - h. [Vibration Isolation]
 - i. [Vibration Management Corp.]
 - j. [VMC GROUP]
 - k. <Insert manufacturer's name>
3. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Minimum deflection as indicated on Drawings.
8. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
9. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
10. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
11. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.15 SNUBBERS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [CADDY; brand of nVent Electrical plc]
 2. [Kinetics Noise Control, Inc]
 3. [Mason Industries, Inc.]

4. [Vibration Management Corp.]
5. [VMC GROUP]
6. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [CADDY; brand of nVent Electrical plc]
2. [Kinetics Noise Control, Inc]
3. [Mason Industries, Inc.]
4. [Vibration Management Corp.]
5. [VMC GROUP]
6. <Insert manufacturer's name>

C. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be prequalified in accordance with ACI 355.2 testing and designated in accordance with [ACI 318-08 Appendix D for 2009 IBC][ACI 318-11 Appendix D for 2012 IBC][ACI 318-14 Ch. 17 for 2015 or 2018 IBC].
2. Preset Concrete Inserts: Prequalified in accordance with ICC-ES AC446 testing.
3. Anchors in Masonry: Design in accordance with TMS 402.
4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
5. Resilient Cushion: Maximum **1/4-inch (6-mm)** air gap, and minimum **1/4 inch (6 mm)** thick.

2.16 RESTRAINTS - RIGID TYPE

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. [Atkore Unistrut]
2. [CADDY; brand of nVent Electrical plc]
3. [California Dynamics Corporation]
4. [Cooper B-line; brand of Eaton, Electrical Sector]
5. [Hilti, Inc.]
6. [Isolation Technology, Inc]
7. [TOLCO Incorporated]
8. [VMC GROUP]
9. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [Atkore Unistrut]
2. [CADDY; brand of nVent Electrical plc]
3. [California Dynamics Corporation]
4. [Cooper B-line; brand of Eaton, Electrical Sector]
5. [Hilti, Inc.]
6. [Isolation Technology, Inc]
7. [TOLCO Incorporated]
8. [VMC GROUP]
9. <Insert manufacturer's name>

- C. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.17 RESTRAINTS - CABLE TYPE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[CADDY; brand of nVent Electrical plc]**
 2. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 3. **[Gripple Inc.]**
 4. **[Loos & Co. Inc.]**
 5. **[VMC GROUP]**
 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[CADDY; brand of nVent Electrical plc]**
 2. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 3. **[Gripple Inc.]**
 4. **[Loos & Co. Inc.]**
 5. **[VMC GROUP]**
 6. **<Insert manufacturer's name>**
- C. Restraint Cables: **[ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel][ASTM A492 stainless steel]** cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.
- D. Restraint cable assembly and cable fittings must comply with **[ASCE/SEI 19-10][ASCE/SEI 19-16]**. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.18 RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Atkore Unistrut]**
 2. **[CADDY; brand of nVent Electrical plc]**
 3. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 4. **[Hilti, Inc.]**
 5. **[Loos & Co. Inc.]**
 6. **[Mason Industries, Inc.]**
 7. **[TOLCO Incorporated]**
 8. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's**

name; product name or designation> or comparable product by one of the following:

1. [Atkore Unistrut]
2. [CADDY; brand of nVent Electrical plc]
3. [Cooper B-line; brand of Eaton, Electrical Sector]
4. [Hilti, Inc.]
5. [Loos & Co. Inc.]
6. [Mason Industries, Inc.]
7. [TOLCO Incorporated]
8. <Insert manufacturer's name>

- C. Hanger-Rod Stiffener: [Steel tube or steel slotted-support-system sleeve with internally bolted connections][Reinforcing steel angle clamped] to hanger rod.
- D. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to [rigid channel bracings][and][restraint cables].
- E. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- F. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- G. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.19 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Atkore Unistrut]
 - b. [Cooper B-line; brand of Eaton, Electrical Sector]
 - c. [Hilti, Inc.]
 - d. [Mason Industries, Inc.]
 - e. [Powers Fasteners]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Atkore Unistrut]
 - b. [Cooper B-line; brand of Eaton, Electrical Sector]
 - c. [Hilti, Inc.]
 - d. [Mason Industries, Inc.]
 - e. [Powers Fasteners]
 - f. <Insert manufacturer's name>

3. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Atkore Unistrut]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - c. **[Hilti, Inc.]**
 - d. **[Mason Industries, Inc.]**
 - e. **[Powers Fasteners]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Atkore Unistrut]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - c. **[Hilti, Inc.]**
 - d. **[Mason Industries, Inc.]**
 - e. **[Powers Fasteners]**
 - f. **<Insert manufacturer's name>**
 3. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.
- C. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of [ASCE/SEI 7-05, Ch. 13][ASCE/SEI 7-10, Ch. 13][ASCE/SEI 7-16, Ch. 13].**
1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
 2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

D. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp (7.46 kW) that is not vibration isolated.

1. Undercut expansion anchors are permitted.

2.20 CONCRETE INSERTS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Atkore Unistrut]**

2. [Cooper B-line; brand of Eaton, Electrical Sector]
3. [Hilti, Inc.]
4. [Mason Industries, Inc.]
5. [Powers Fasteners]
6. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Atkore Unistrut]
2. [Cooper B-line; brand of Eaton, Electrical Sector]
3. [Hilti, Inc.]
4. [Mason Industries, Inc.]
5. [Powers Fasteners]
6. <Insert manufacturer's name>

C. Provide preset concrete inserts that are prequalified in accordance with ICC-ES AC466 testing.

D. Comply with ANSI/MSS SP-58.

2.21 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [CADDY; brand of nVent Electrical plc]
2. [California Dynamics Corporation]
3. [Kinetics Noise Control, Inc]
4. [Mason Industries, Inc.]
5. [NOVIA; a division of Carpenter & Paterson]
6. [Vibration Eliminator Co., Inc]
7. [Vibration Isolation]
8. [Vibration Management Corp.]
9. [VMC GROUP]
10. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [CADDY; brand of nVent Electrical plc]
2. [California Dynamics Corporation]
3. [Kinetics Noise Control, Inc]
4. [Mason Industries, Inc.]
5. [NOVIA; a division of Carpenter & Paterson]
6. [Vibration Eliminator Co., Inc]
7. [Vibration Isolation]
8. [Vibration Management Corp.]
9. [VMC GROUP]
10. <Insert manufacturer's name>

C. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm)

clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.

- a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- D. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.
1. Design Requirements: Lowest possible mounting height with not less than **1-inch (25-mm)** clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- E. Concrete Inertia Base: **[Factory-fabricated][or][field-fabricated]**, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than **1-inch (25-mm)** clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.22 RESTRAINED ISOLATION ROOF-CURB RAILS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[CADDY; brand of nVent Electrical plc]**
 2. **[California Dynamics Corporation]**
 3. **[Kinetics Noise Control, Inc]**
 4. **[NOVIA; a division of Carpenter & Paterson]**
 5. **[Thybar Corporation]**
 6. **[Vibration Eliminator Co., Inc]**
 7. **[Vibration Management Corp.]**
 8. **[VMC GROUP]**
 9. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[CADDY; brand of nVent Electrical plc]**
 2. **[California Dynamics Corporation]**
 3. **[Kinetics Noise Control, Inc]**
 4. **[NOVIA; a division of Carpenter & Paterson]**
 5. **[Thybar Corporation]**
 6. **[Vibration Eliminator Co., Inc]**
 7. **[Vibration Management Corp.]**
 8. **[VMC GROUP]**
 9. **<Insert manufacturer's name>**
- C. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment.
- D. Upper Frame: Shall provide continuous and captive support for equipment.
- E. Lower Support Assembly: Shall be formed sheet metal section containing adjustable and removable steel springs that support upper frame. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials and shall be insulated with a minimum of **2 inches (50 mm)** of rigid glass-fiber insulation on inside of assembly.
1. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with integrity of roof.
 2. Minimum deflection as indicated on Drawings.
- F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation **[and wind-load control]** devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by **[an evaluation service member of ICC-ES][OSHDP][an agency acceptable to authorities having jurisdiction]**.

- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to wind-load forces.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static and wind force loads within specified loading limits.

3.3 INSTALLATION OF VIBRATION AND WIND-LOADCONTROL DEVICES

- A. Provide vibration **[and wind-load]**control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.
- B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- C. Installation of vibration isolators **[and wind-load restraints]** must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- D. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- E. Equipment Restraints:
 - 1. Install snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds **0.125 inch (3.2 mm)**.
 - 3. Install wind-load-restraint devices using methods approved by **[an evaluation service member of ICC-ES][OSHDP][an agency acceptable to authorities having jurisdiction]** that provides required submittals for component.
- F. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of **[40 feet (12 m)]<Insert dimension> o.c.**, and longitudinal supports a maximum of **[80 feet (24 m)]<Insert dimension> o.c.**
 - 3. Brace a change of direction longer than **12 feet (3.7 m)**.
- G. Install wind-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.
- H. Install wind-load-restraint devices using methods approved by **[an evaluation service member of ICC-ES][OSHDP][an agency acceptable to authorities having jurisdiction]** that provides required submittals for component.
- I. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- J. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- K. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

L. Post-Installed Concrete Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 INSTALLATION OF AIR-SPRING ISOLATORS

A. Independent Isolator Installation:

1. Install automatic leveling valve into each air isolator.
2. Inflate each isolator to **[height][and][pressure]** specified on Drawings.

B. Pressure-Regulated Isolator Installation:

1. Coordinate the constant pressure-regulated air supply to air springs with requirements for piping and connections specified in Section 221513 "General-Service Compressed-Air Piping."
2. Connect all pressure regulators to a single dry, filtered **[facility][constant]** air supply.
3. Inflate isolators to **[height][and][or][pressure]** specified on Drawings.

3.5 ACCOMMODATION OF DIFFERENTIAL MOTION

- A. Provide flexible connections in piping systems where they cross structural joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for piping flexible connections.

3.6 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES

- A. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- B. Coordinate dimensions of equipment bases with requirements of isolated equipment specified in this and other Sections. Where dimensions of base are indicated on Drawings, they may require adjustment to accommodate isolated equipment.

3.7 ADJUSTING

- A. Adjust isolators after system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 - 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - 4. Test at least **[four]<Insert number>** of each type and size of installed anchors and fasteners selected by Architect.
 - 5. Test to 90 percent of rated proof load of device.
 - 6. Measure isolator restraint clearance.
 - 7. Measure isolator deflection.
 - 8. Verify snubber minimum clearances.
 - 9. Test and adjust restrained-air-spring isolator controls and safeties.
- E. Remove and replace malfunctioning units and retest as specified above.
- F. Prepare test and inspection reports.

END OF SECTION 23 05 48 13



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 05 48 13	21 05 48 00	Vibration And Seismic Controls For Fire-Suppression Piping And Equipment
23 05 48 13	22 05 48 00	Vibration And Seismic Controls For Plumbing Piping And Equipment
23 05 48 13	22 15 13 00	General-Service Compressed-Air Piping
23 05 48 13	23 05 00 00a	Coatings for HVAC
23 05 48 13	23 05 48 00	Vibration and Seismic Controls for HVAC
23 05 48 13	23 05 48 00a	Vibration Instruments
23 05 48 13	23 21 13 00	Hydronic Piping
23 05 48 13	22 11 16 00d	Steam And Condensate Piping
23 05 48 13	23 23 00 00	Refrigerant Piping



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 05 53 00 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Warning tape.
4. Pipe labels.
5. Duct labels.
6. Stencils.
7. Valve tags.
8. Warning tags.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment-Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve-numbering scheme.
- E. Valve Schedules: Provide for each piping system. Include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Brady Corporation]**
 - b. **[Carlton Industries, LP]**
 - c. **[Champion America]**
 - d. **[Craftmark Pipe Markers]**
 - e. **[emedco]**
 - f. **[Kolbi Pipe Marker Co.]**
 - g. **[LEM Products Inc.]**

- h. [Marking Services Inc.]
- i. [Pipemarker.com; Brimar Industries, Inc.]
- j. [Seton Identification Products; a Brady Corporation company]
- k. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Brady Corporation]
- b. [Carlton Industries, LP]
- c. [Champion America]
- d. [Craftmark Pipe Markers]
- e. [emedco]
- f. [Kolbi Pipe Marker Co.]
- g. [LEM Products Inc.]
- h. [Marking Services Inc.]
- i. [Pipemarker.com; Brimar Industries, Inc.]
- j. [Seton Identification Products; a Brady Corporation company]
- k. <Insert manufacturer's name>

3. Material and Thickness: [Brass, 0.032-inch (0.8-mm)][stainless steel, 0.025-inch (0.64-mm)][aluminum, 0.032-inch (0.8-mm)][anodized aluminum, 0.032-inch (0.8-mm)] minimum thickness, with predrilled or stamped holes for attachment hardware.
4. Letter and Background Color: As indicated for specific application under Part 3.
5. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch (64 by 19 mm)**.
6. Minimum Letter Size: **1/4 inch (6.4 mm)** for name of units if viewing distance is less than **24 inches (600 mm)**, **1/2 inch (13 mm)** for viewing distances of up to **72 inches (1830 mm)**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Brady Corporation]
 - b. [Carlton Industries, LP]
 - c. [Champion America]
 - d. [Craftmark Pipe Markers]
 - e. [emedco]
 - f. [Kolbi Pipe Marker Co.]
 - g. [LEM Products Inc.]
 - h. [Marking Services Inc.]
 - i. [Pipemarker.com; Brimar Industries, Inc.]
 - j. [Seton Identification Products; a Brady Corporation company]
 - k. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. [Brady Corporation]
 - b. [Carlton Industries, LP]
 - c. [Champion America]
 - d. [Craftmark Pipe Markers]
 - e. [emedco]
 - f. [Kolbi Pipe Marker Co.]
 - g. [LEM Products Inc.]
 - h. [Marking Services Inc.]
 - i. [Pipemarker.com; Brimar Industries, Inc.]
 - j. [Seton Identification Products; a Brady Corporation company]
 - k. <Insert manufacturer's name>
3. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, [1/16 inch (1.6 mm)][1/8 inch (3.2 mm)]<Insert dimension> thick, with predrilled holes for attachment hardware.
 4. Letter and Background Color: As indicated for specific application under Part 3.
 5. Maximum Temperature: Able to withstand temperatures of up to **160 deg F (71 deg C)**.
 6. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch (64 by 19 mm)**.
 7. Minimum Letter Size: **1/4 inch (6.4 mm)** for name of units if viewing distance is less than **24 inches (600 mm)**, **1/2 inch (13 mm)** for viewing distances of up to **72 inches (1830 mm)**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 8. Fasteners: Stainless steel rivets or self-tapping screws.
 9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

2.2 WARNING SIGNS AND LABELS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. [Brady Corporation]
 2. [Carlton Industries, LP]
 3. [Champion America]
 4. [Craftmark Pipe Markers]
 5. [emedco]
 6. [LEM Products Inc.]
 7. [Marking Services Inc.]
 8. [National Marker Company]
 9. [Pipemarker.com; Brimar Industries, Inc.]
 10. [Seton Identification Products; a Brady Corporation company]
 11. [Stranco, Inc.]
 12. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. [Brady Corporation]

2. [Carlton Industries, LP]
3. [Champion America]
4. [Craftmark Pipe Markers]
5. [emedco]
6. [LEM Products Inc.]
7. [Marking Services Inc.]
8. [National Marker Company]
9. [Pipemarker.com; Brimar Industries, Inc.]
10. [Seton Identification Products; a Brady Corporation company]
11. [Stranco, Inc.]
12. <Insert manufacturer's name>

- C. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, [1/16 inch (1.6 mm)][1/8 inch (3.2 mm)]<Insert dimension> thick, with predrilled holes for attachment hardware.
- D. Letter and Background Color: As indicated for specific application under Part 3.
- E. Maximum Temperature: Able to withstand temperatures of up to **160 deg F (71 deg C)**.
- F. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch (64 by 19 mm)**.
- G. Minimum Letter Size: **1/4 inch (6.4 mm)** for name of units if viewing distance is less than **24 inches (600 mm)**, **1/2 inch (13 mm)** for viewing distances of up to **72 inches (1830 mm)**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- H. Fasteners: Stainless steel rivets or self-taping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA70E[**and other applicable codes and standards**].
- K. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 WARNING TAPE

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [Brady Corporation]
 2. [Craftmark Pipe Markers]
 3. [National Marker Company]
 4. [Pipemarker.com; Brimar Industries, Inc.]
 5. [Seton Identification Products; a Brady Corporation company]
 6. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Brady Corporation]
 2. [Craftmark Pipe Markers]

3. [National Marker Company]
4. [Pipemarker.com; Brimar Industries, Inc.]
5. [Seton Identification Products; a Brady Corporation company]
6. <Insert manufacturer's name>

- C. Material: Vinyl.
- D. Minimum Thickness: **0.005 inch (0.12 mm)**.
- E. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.
- F. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.
- G. Maximum Temperature: **160 deg F (70 deg C)**.
- H. Minimum Width: [**2 inches (50 mm)**][**4 inches (100 mm)**].

2.4 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. [Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.]
2. [Brady Corporation]
3. [Carlton Industries, LP]
4. [Champion America]
5. [Craftmark Pipe Markers]
6. [emedco]
7. [Kolbi Pipe Marker Co.]
8. [LEM Products Inc.]
9. [Marking Services Inc.]
10. [Pipemarker.com; Brimar Industries, Inc.]
11. [Seton Identification Products; a Brady Corporation company]
12. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.]
2. [Brady Corporation]
3. [Carlton Industries, LP]
4. [Champion America]
5. [Craftmark Pipe Markers]
6. [emedco]
7. [Kolbi Pipe Marker Co.]
8. [LEM Products Inc.]
9. [Marking Services Inc.]
10. [Pipemarker.com; Brimar Industries, Inc.]
11. [Seton Identification Products; a Brady Corporation company]
12. <Insert manufacturer's name>

- C. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.

- D. Letter and Background Color: As indicated for specific application under Part 3.
- E. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to **[partially cover][cover full]** circumference of pipe and to attach to pipe without fasteners or adhesive.
- F. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- G. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:
 - 1. Pipe size.
 - 2. Flow-Direction Arrows: Include flow-direction arrows on **[main]** distribution piping. Arrows may be either integral with label or applied separately.
 - 3. Lettering Size: **[Size letters in accordance with ASME A13.1 for piping][At least 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances].**

2.5 DUCT LABELS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Brady Corporation]**
 - 2. **[Carlton Industries, LP]**
 - 3. **[Champion America]**
 - 4. **[Craftmark Pipe Markers]**
 - 5. **[emedco]**
 - 6. **[Kolbi Pipe Marker Co.]**
 - 7. **[LEM Products Inc.]**
 - 8. **[Marking Services Inc.]**
 - 9. **[Pipemarker.com; Brimar Industries, Inc.]**
 - 10. **[Seton Identification Products; a Brady Corporation company]**
 - 11. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Brady Corporation]**
 - 2. **[Carlton Industries, LP]**
 - 3. **[Champion America]**
 - 4. **[Craftmark Pipe Markers]**
 - 5. **[emedco]**
 - 6. **[Kolbi Pipe Marker Co.]**
 - 7. **[LEM Products Inc.]**
 - 8. **[Marking Services Inc.]**
 - 9. **[Pipemarker.com; Brimar Industries, Inc.]**
 - 10. **[Seton Identification Products; a Brady Corporation company]**
 - 11. **<Insert manufacturer's name>**
- C. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **[1/16 inch (1.6 mm)][1/8 inch (3.2 mm)]<Insert dimension>** thick, and having predrilled holes for attachment hardware.

- D. Letter and Background Color: As indicated for specific application under Part 3.
- E. Maximum Temperature: Able to withstand temperatures up to **160 deg F (71 deg C)**.
- F. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch (64 by 19 mm)**.
- G. Minimum Letter Size: **1/4 inch (6.4 mm)** for name of units if viewing distance is less than **24 inches (600 mm)**, **1/2 inch (13 mm)** for viewing distances of up to **72 inches (1830 mm)**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- H. Fasteners: Stainless steel rivets or self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:
 - 1. Duct size.
 - 2. Flow-Direction Arrows: Include flow-direction arrows on[**main**] distribution ducts. Arrows may be either integral with label or may be applied separately.
 - 3. Lettering Size: **[Size letters in accordance with ASME A13.1 for piping][At least 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances]**.

2.6 STENCILS

- A. Stencils for Piping:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Craftmark Pipe Markers]**
 - b. **[Kolbi Pipe Marker Co.]**
 - c. **[Marking Services Inc.]**
 - d. **[Pipemarker.com; Brimar Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Craftmark Pipe Markers]**
 - b. **[Kolbi Pipe Marker Co.]**
 - c. **[Marking Services Inc.]**
 - d. **[Pipemarker.com; Brimar Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
 - 3. Lettering Size: **[Size letters in accordance with ASME A13.1 for piping][At least 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances]**.
 - 4. Stencil Material: Aluminum, brass, or fiberboard.

5. Stencil Paint: Exterior, gloss, **[alkyd enamel][acrylic enamel]<Insert paint type>** in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
6. Identification Paint: Exterior, **[alkyd enamel][acrylic enamel]<Insert paint type>**. Paint may be in pressurized spray-can form.
7. Letter and Background Color: As indicated for specific application under Part 3.

B. Stencils for Ducts:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Craftmark Pipe Markers]**
 - b. **[Kolbi Pipe Marker Co.]**
 - c. **[Marking Services Inc.]**
 - d. **[Pipemarker.com; Brimar Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Craftmark Pipe Markers]**
 - b. **[Kolbi Pipe Marker Co.]**
 - c. **[Marking Services Inc.]**
 - d. **[Pipemarker.com; Brimar Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Lettering Size: Minimum letter height of **1-1/4 inches (32 mm)** for viewing distances of up to **15 ft. (4-1/2 m)** and proportionately larger lettering for greater viewing distances.
4. Stencil Material: **[Aluminum][Brass][Fiberboard][Fiberboard or metal]<Insert material>**.
5. Stencil Paint: Exterior, gloss, **[alkyd enamel][acrylic enamel]<Insert paint type>**. Paint may be in pressurized spray-can form.
6. Identification Paint: Exterior, **[alkyd enamel][acrylic enamel]<Insert paint type>**. Paint may be in pressurized spray-can form.
7. Letter and Background Color: Color as indicated for specific application under Part 3.

C. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Craftmark Pipe Markers]**
 - b. **[Kolbi Pipe Marker Co.]**
 - c. **[Marking Services Inc.]**
 - d. **[Pipemarker.com; Brimar Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Craftmark Pipe Markers]**
 - b. **[Kolbi Pipe Marker Co.]**
 - c. **[Marking Services Inc.]**
 - d. **[Pipemarker.com; Brimar Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Lettering Size: Minimum letter height of **1/2 inch (13 mm)** for viewing distances of up to **72 inches (1830 mm)** and proportionately larger lettering for greater viewing distances.
 4. Stencil Material: **[Aluminum][Brass][Fiberboard][Fiberboard or metal]<Insert material>**.
 5. Stencil Paint: Exterior, gloss, **[alkyd enamel][acrylic enamel]<Insert paint type>**. Paint may be in pressurized spray-can form.
 6. Identification Paint: Exterior, **[alkyd enamel][acrylic enamel]<Insert paint type>**. Paint may be in pressurized spray-can form.
 7. Letter and Background Color: As indicated for specific application under Part 3.

2.7 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.]**
 2. **[Brady Corporation]**
 3. **[Carlton Industries, LP]**
 4. **[Champion America]**
 5. **[Craftmark Pipe Markers]**
 6. **[emedco]**
 7. **[Kolbi Pipe Marker Co.]**
 8. **[LEM Products Inc.]**
 9. **[Marking Services Inc.]**
 10. **[Pipemarker.com; Brimar Industries, Inc.]**
 11. **[Seton Identification Products; a Brady Corporation company]**
 12. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.]**
 2. **[Brady Corporation]**
 3. **[Carlton Industries, LP]**
 4. **[Champion America]**
 5. **[Craftmark Pipe Markers]**
 6. **[emedco]**
 7. **[Kolbi Pipe Marker Co.]**
 8. **[LEM Products Inc.]**
 9. **[Marking Services Inc.]**
 10. **[Pipemarker.com; Brimar Industries, Inc.]**
 11. **[Seton Identification Products; a Brady Corporation company]**
 12. **<Insert manufacturer's name>**
- C. Description: Stamped or engraved with **1/4-inch (6.4-mm)** letters for piping system abbreviation and **1/2-inch (13-mm)** numbers.
 1. Tag Material: **[Brass, 0.04-inch (1.0-mm)][stainless steel, 0.024-inch (0.61-mm)][aluminum, 0.031-inch (0.79-mm)][or][anodized aluminum, 0.031-inch (0.79-mm)]** minimum thickness, with

- predrilled or stamped holes for attachment hardware.
 2. Fasteners: Brass [wire][link chain][or][beaded chain][or][S-hook].
- D. Letter and Background Color: As indicated for specific application under Part 3.
- E. Valve Schedules: For each piping system, on **8-1/2-by-11-inch (A4)** bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
1. Include valve-tag schedule in operation and maintenance data.

2.8 WARNING TAGS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Brady Corporation]**
 2. **[Champion America]**
 3. **[Craftmark Pipe Markers]**
 4. **[emedco]**
 5. **[Kolbi Pipe Marker Co.]**
 6. **[LEM Products Inc.]**
 7. **[Marking Services Inc.]**
 8. **[Pipemarker.com; Brimar Industries, Inc.]**
 9. **[Seton Identification Products; a Brady Corporation company]**
 10. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Brady Corporation]**
 2. **[Champion America]**
 3. **[Craftmark Pipe Markers]**
 4. **[emedco]**
 5. **[Kolbi Pipe Marker Co.]**
 6. **[LEM Products Inc.]**
 7. **[Marking Services Inc.]**
 8. **[Pipemarker.com; Brimar Industries, Inc.]**
 9. **[Seton Identification Products; a Brady Corporation company]**
 10. **<Insert manufacturer's name>**
- C. Description: Preprinted[**or partially preprinted**] accident-prevention tags of plasticized card stock[**with matte finish suitable for writing**].
1. Size: **[3 by 5-1/4 inches (75 by 133 mm) minimum][Approximately 4 by 7 inches (100 by 178 mm)]<Insert size>**.
 2. Fasteners: **[Brass grommet and wire][Reinforced grommet and wire or string]**.
 3. Nomenclature: Large-size primary caption, such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 4. Letter and Background Color: As indicated for specific application under Part 3.



PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 INSTALLATION, GENERAL REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.
- D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

- A. Permanently fasten labels on each item of mechanical equipment.
- B. Sign and Label Colors:
 - 1. **[White letters on an ANSI Z535.1 safety-blue background]<Insert colors>.**
- C. Locate equipment labels where accessible and visible.
- D. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where arc-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E[, **and other applicable codes and standards**].

3.4 INSTALLATION OF WARNING TAPE

- A. Warning Tape Color and Pattern: **[Yellow background with black diagonal stripes]<Insert color, marking pattern, text>.**
- B. Install warning tape on pipes and ducts, with cross-designated walkways providing less than **6 ft. (2 m)** of clearance.
- C. Locate tape so as to be readily visible from the point of normal approach.

3.5 INSTALLATION OF PIPE LABELS

- A. Piping Color Coding: Painting of piping is specified in **[Section 099123 "Interior Painting."][Section 099600 "High-Performance Coatings."]**
- B. Install pipe labels showing service and flow direction with permanent adhesive on pipes.
- C. Stenciled Pipe Label Option: Stenciled labels showing service and flow direction may be provided

instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, [**with painted, color-coded bands or rectangles**] on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

D. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Within **3 ft. (1 m)** of each valve and control device.
2. At access doors, manholes, and similar access points that permit view of concealed piping.
3. Within **3 ft. (1 m)** of equipment items and other points of origination and termination.
4. Spaced at maximum intervals of **[25 ft. (8 m)]<Insert dimension>** along each run. Reduce intervals to **[10 ft. (3.0 m)]<Insert dimension>** in areas of congested piping, ductwork, and equipment.

E. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of **125 deg F (52 deg C)** or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.

F. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

G. Pipe-Label Color Schedule:

1. Chilled-Water Piping: **[White letters on an ANSI Z535.1 safety-green background]<Insert colors>**.
2. Condenser-Water Piping: **[White letters on an ANSI Z535.1 safety-green background]<Insert colors>**.
3. Heating Water Piping: **[White letters on an ANSI Z535.1 safety-green background]<Insert colors>**.
4. Refrigerant Piping: **[White letters on an ANSI Z535.1 safety-blue background]<Insert colors>**.
5. Low-Pressure Steam Piping: **[Black letters on an ANSI Z535.1 safety-yellow background][White letters on an ANSI Z535.1 safety-green background]<Insert colors>**.
6. High-Pressure Steam Piping: **[Black letters on an ANSI Z535.1 safety-yellow background][White letters on an ANSI Z535.1 safety-green background]<Insert colors>**.
7. Steam Condensate Piping: **[Black letters on an ANSI Z535.1 safety-yellow background][White letters on an ANSI Z535.1 safety-green background]<Insert colors>**.
8. Toxic and Corrosive Fluids: **[Black letters on an ANSI Z535.1 safety-orange background]<Insert colors>**.
9. Flammable Fluids: **[Black letters on an ANSI Z535.1 safety-yellow background]<Insert colors>**.
10. Combustible Fluids: **[White letters on an ANSI Z535.1 safety-brown background]<Insert colors>**.
11. Potable and Other Water: **[White letters on an ANSI Z535.1 safety-green background]<Insert colors>**.
12. Compressed Air: **[White letters on an ANSI Z535.1 safety-blue background]<Insert colors>**.
13. **<Insert additional systems and colors as required>**.

3.6 INSTALLATION OF DUCT LABELS

A. Install **[plastic-laminated][self-adhesive]** duct labels showing service and flow direction with permanent adhesive on air ducts.

1. Provide labels in the following color codes:
 - a. For air supply ducts: **[White letters on blue background]<Insert color>**.
 - b. For air return ducts: **[White letters on blue background]<Insert color>**.
 - c. For exhaust-, outside-, relief-, return-, and mixed-air ducts: **[White letters on blue background]<Insert color>**.
 - d. **[Insert additional systems and colors as needed]**.
- B. Stenciled Duct-Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.

1. For all air ducts: **[Black letters on white background]<Insert color>**.

- C. Locate label near each point where ducts enter into and exit from concealed spaces and at maximum intervals of **[20 ft. (6 m)]** where exposed or are concealed by removable ceiling system.

- D. Stenciled Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. **[Black letters on White background]<Insert color>**.

3.7 INSTALLATION OF VALVE TAGS

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below.

1. Valve-Tag Size and Shape:

- a. Chilled Water: **[1-1/2 inches (38 mm)][2 inches (50 mm)], [round][square]<Insert shape>**.
- b. Condenser Water: **[1-1/2 inches (38 mm)][2 inches (50 mm)], [round][square]<Insert shape>**.
- c. Refrigerant: **[1-1/2 inches (38 mm)][2 inches (50 mm)], [round][square]<Insert shape>**.
- d. Hot Water: **[1-1/2 inches (38 mm)][2 inches (50 mm)], [round][square]<Insert shape>**.
- e. Gas: **[1-1/2 inches (38 mm)][2 inches (50 mm)], [round][square]<Insert shape>**.
- f. Low-Pressure Steam: **[1-1/2 inches (38 mm)][2 inches (50 mm)], [round][square]<Insert shape>**.
- g. High-Pressure Steam: **[1-1/2 inches (38 mm)][2 inches (50 mm)], [round][square]<Insert shape>**.
- h. Steam Condensate: **[1-1/2 inches (38 mm)][2 inches (50 mm)], [round][square]<Insert shape>**.

2. Valve-Tag Colors:

- a. For each piping system, use the same lettering and background coloring system on valve tags as used for the Pipe Label Schedule text and background.



3.8 INSTALLATION OF WARNING TAGS

- A. Warning Tag Color: **[Black letters on an ANSI Z535.1 safety-yellow background]<Insert color>.**
- B. Attach warning tags, with proper message, to equipment and other items where **[indicated on Drawings][scheduled]**.

END OF SECTION 23 05 53 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 05 53 00	22 05 53 00	Identification for Plumbing Piping and Equipment
23 05 53 00	23 05 00 00a	Coatings for HVAC



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 05 66 00 - ANTIMICROBIAL ULTRAVIOLET LAMP SYSTEMS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Antimicrobial UV-C lamp systems for large air-handling units.
2. Antimicrobial UV-C lamp systems for packaged air-handling units.
3. Controls.

1.2 DEFINITIONS

- A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- B. UV-C: Ultraviolet-C short-wave spectrum.
- C. UV-C Lamp System: Unit including UV lamp, power supply, housing, and supports.
- D. UVGI: Ultraviolet germicidal irradiation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product description with complete technical data, performance data, and product specification sheets.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating power, distribution range, control signal over range, default control signal with loss of power, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Installation instructions, including factors affecting performance.

B. Sustainable Design Submittals:

1. Product Data: For lamps, indicating mercury content and lamp life.

C. Shop Drawings: For each UV-C lamp system.

1. Include plans, elevations, sections, mounting, and attachment details.
2. Include details of UV-C lamp system assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.



1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Elevations and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Structural members of equipment to which lamp systems will be attached.
 - 2. Air-handling unit penetrations.
 - 3. Access points for service of lamps and power supplies.
 - 4. Power[**and communications**] connections.
- B. Contractor's Construction Schedule.
- C. Application for Payment and schedule of values.
- D. Qualification Data: For testing laboratory providing data for UV lamps and fixtures.
- E. Product Certificates: For each type of UV lamp, fixture, and system.
- F. Product Test Reports: For each type of UV lamp and fixture, for tests performed by [manufacturer and witnessed by a qualified testing agency][a qualified testing agency].
- G. Sample Warranty: For manufacturer's warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lamp systems to include in operation and maintenance manuals.
 - 1. Provide a list of all lamp and fixture types used on Project.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. UV-C Lamps: [**10 for every 100**]**<Insert quantity>** of each type and rating installed. Furnish no fewer than one of each type.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period, System: [**Five**]**<Insert number>** years from date of Substantial Completion.
 - 2. Warranty Period, Lamp: [**One**]**<Insert number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ANTIMICROBIAL ULTRAVIOLET LAMP SYSTEMS FOR HVAC

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Aerapy, LLC]**
2. **[American Air & Water, Inc.]**
3. **[American Ultraviolet]**
4. **[Atlantic Ultraviolet Corporation]**
5. **[Carrier Global Corporation]**
6. **[DiversiTech Corp.]**
7. **[Dust Free, LP]**
8. **[Fresh-Aire UV; a Triatomic Environmental Inc. company]**
9. **[Steril-Aire, Inc.]**
10. **[Ultravation, Inc.]**
11. **[UV Resources]**
12. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Aerapy, LLC]**
2. **[American Air & Water, Inc.]**
3. **[American Ultraviolet]**
4. **[Atlantic Ultraviolet Corporation]**
5. **[Carrier Global Corporation]**
6. **[DiversiTech Corp.]**
7. **[Dust Free, LP]**
8. **[Fresh-Aire UV; a Triatomic Environmental Inc. company]**
9. **[Steril-Aire, Inc.]**
10. **[Ultravation, Inc.]**
11. **[UV Resources]**
12. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

- C. ASHRAE Compliance:

1. Test UV-C lamp systems according to ASHRAE 185.1, "Method of Testing UV-C Lights for Use in Air-Handling Units or Air Ducts to Inactivate Airborne Microorganisms."
2. Test UV-C lamp systems according to ASHRAE 185.2, "Method of Testing Ultraviolet Lamps for Use in HVAC&R Units or Air Ducts on Irradiated Surfaces."

2.3 ANTIMICROBIAL UV-C LAMP SYSTEMS FOR LARGE AIR-HANDLING UNITS

- A. Description: UV-C lamp system consisting of power supply, power supply housing, wiring, UV lamp(s), lamp plug, lamp plug protector, encapsulated lamp, and lamp holder.
- B. Power Supply: UL listed, single phase, 120 or 277 V ac, 50 or 60 Hz, with a programmed rapid start.
 - 1. Power Factor: High power factor, Class P, Sound Rated A, Type 1 Outdoor, and with inherent thermal protection and without polychlorinated biphenyl.
 - 2. Operating Temperature: From [34 to 194 deg F (1 to 90 deg C)]<Insert operating temperature(s)>.
 - 3. Wiring Harness: Plug and play.
 - 4. Power Consumption: Maximum of [15 W/sq. ft. (161.5 W/per sq. m)]<Insert value>.
 - 5. Electrical Connection: Single electrical connection[with service disconnect].
- C. UV-C Lamps: Encapsulated lamps, with lamp wattage and model number visibly printed on all lamps, less than 8 Mg of mercury in each lamp. UV-C lamps do not produce ozone.
 - 1. Quantity and Type: [One 145-W UV-C lamp][One 75-W UV-C lamp]<Insert value and type of lamps>.
 - 2. Output: UV-C energy, primarily at the 253.7-nm wavelength with a 360-degree energy distribution.
 - 3. Operating Temperature: From [34 to 158 deg F (1 to 70 deg C)]<Insert operating temperature(s)>, 100 percent relative humidity, at any velocity.
 - 4. Lamp Protection: Hermetically sealed with a thin layer of UV-C-transmissible fluorinated ethylene propylene to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.
 - 5. Lamp Life: Minimum of [9000 hours]<Insert time> with greater than 85 percent of initial output at end of lamp life.
- D. Power Supply Housing: Galvanized-steel, 20-gauge (0.813-mm), powder-coated finish, for installation inside or outside of air-handling units or plenums.
 - 1. Power Supply Capacity: [One][Two][Four][Six]<Insert number>.
 - 2. Provide a suitable separate NEMA enclosure, for field installation of power supply, on the exterior of an outside air-handling unit.
- E. Wiring Loom: UV-C-resistant jacket materials with internal aluminum/Mylar shield.
 - 1. Conduit: Loom covered with UL flexible metal conduit, galvanized.
- F. Lamp Plug, Holder, and Lamp Clamp: Four-pin type accommodates a single-ended high output lamp.
 - 1. Lamp Plug and Holder Construction: UV-resistant materials designed to connect lamp to the plug.
 - 2. UL Listing: Listed and labeled to UL.
 - 3. Lamp Clamp Construction: UV-resistant materials to ensure a watertight connection. A seal between the single-ended UV lamp and the lamp plug prevents electrical shock, connection shorts, and lamp or power supply failure, from lamp pin oxidation or arcing.
 - 4. Position: Adjustable positioning of lamp holder and lamp clamp.
- G. Lamp Holsters: Dual lamp holsters permanently affixed within the irradiated cavity to interior surface of an air-handling unit or to vertical supports.
 - 1. Lamp Holster Construction: UV-C-resistant materials for fastening strength.
 - 2. Positioning: Flexible lamp positioning allows ease of lamp removal.

2.4 ANTICMICROBIAL UV-C LAMP SYSTEMS FOR PACKAGED AIR-HANDLING UNITS

- A. Description: Factory-assembled UV-C lamp system with **[NEMA 4X]** power supply housing, four each, **1/2- or 3/4-inch (12.7- or 19-mm)** electrical knock-outs, power supply with integrated lamp plug, lamp compression nut, and UV lamp.
- B. Power Supply: UL listed, single phase, 120 or 240 V ac, 50 or 60 Hz, with a programmed rapid start.
1. Power Factor: High power factor, Class P, Sound Rated A, Type 1 Outdoor, and with inherent thermal protection and without polychlorinated biphenyl.
 2. Output: Automatically sense and maximize lamp output, energy efficiency, and reliability for lamp lengths from **17 to 61 inches (432 to 1549 mm)**.
 3. Operating Temperature: From **34 to 194 deg F (1 to 90 deg C)**.
 4. Safety: Integral interlock switch on power supply.
 5. Power Consumption: Maximum **15 W/sq. ft. (161.5 W/sq. m)**.
 6. Electrical Connection: Single electrical connection[**with service disconnect**].
- C. UV-C Lamps: Encapsulated lamps with lamp wattage and model number visibly printed on all lamps, less than 8 Mg of mercury in each lamp. Lamps do not produce ozone.
1. Quantity and Type: **[One][T5, hot cathode, single-ended, four pin]<Insert number and type of lamps>**.
 2. Output: UV-C energy, primarily at 253.7-nm wavelength with a 360-degree energy distribution.
 3. Base: Long-mount base lamp. Lamp filament extends into the airstream beyond plenum walls and insulation.
 4. Operating Temperature: From **34 to 158 deg F (1 to 70 deg C)**, 100-percent relative humidity, at any velocity.
 5. Lamp Protection: Hermetically sealed with a thin layer of UV-C-transmissible fluorinated ethylene propylene to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.
 6. Lamp Life: Minimum of **[9000 hours]<Insert time>** with greater than 85 percent of initial output at end of lamp life.
- D. Power Supply Housing: High-performance, white polycarbonate for external thermal rejection, equipped with lamp support for lamp lengths up to **61 inches (1549 mm)** and a weathertight cover with an integrated seal. Housing contains all components in one integral assembly for safety and serviceability without tools.
1. Interlock: Disrupt lever on the cover actuates the interlock switch to disconnect or restore power when removed or installed. Padlock eyelets lock the housing cover to guard against unwanted entry.
 2. Surface Installation Mounting: Four mounting holes and gasket to seal housing to the mounting surface.
- E. Lamp Holder and Lamp Clamp: Four-pin type accommodates a single-ended lamp.
1. Lamp Holder Construction: UV-resistant materials and designed to connect the lamp to the plug.
 2. Lamp Clamp Construction: UV-resistant materials to ensure a watertight connection. A seal between the single-ended UV lamp and the lamp plug prevents electrical shock, connection shorts, and lamp or power supply failure, from lamp pin oxidation or arcing.

2.5 CONTROLS

- A. Comply with requirements in Section 230923 "Direct-Digital Control System for HVAC" for control equipment and in Section 230993.11 "Sequence of Operations for HVAC DDC."



- B. Interface with DDC System for HVAC: Factory-installed hardware and software (where applicable) to enable the DDC system for HVAC to monitor, control, and display status and alarms.
- C. Lamp and Power Supply Monitoring: Factory-assembled and tested, consisting of a housing, PC board, and wire block. Construction is designed to withstand installation inside air-handling unit airstream.
 - 1. Housing: Industrial-grade plastic equipped with a direct-reading high-output green LED, two mounting holes, and an external wiring block for wiring to a remote sensing or input device. PC board converts inductive field to a regulated electromotive force of 1 to 5 V dc, maximum.
 - 2. Wiring Block: One positive and one negative terminal for No. 18 AWG and smaller wire.
 - 3. Remote Monitor(s): Installed outside the plenum in a suitable NEMA enclosure to directly or remotely monitor the lamp and power supply combination, with option for a single signal to the DDC system.
- D. Operating Control: Monitor lamp and power supply combination and provide a single on/off signal to the DDC system. UV-C lamp system operates continuously. Interlock UV-C lamp system operation with air-handling unit and component access doors. When an access door is opened, UV-C lamp system is de-energized.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for UV-C lamp system to verify actual locations of UV lamps and electrical connections before UV-C lamp system installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install UV-C lamp systems according to manufacturer's installation manual and drawings unless otherwise indicated.
- B. Install UV lamps in each UV-C lamp system.
- C. Install UV-C lamp systems in locations that are accessible and that will permit servicing and maintenance.
- D. Provide sufficient length of wiring loom to facilitate lamp connection to a remotely located power supply and/or power supply housing, such that lamp and loom can be mounted anywhere in the system.
- E. Seal air-handling unit penetrations to maintain integrity of air-handling unit casings.
- F. Irradiation: Quantity of UV lamps are to be installed to provide an equal distribution of available UV-C energy. When installed, UV-C energy produced shall be of the lowest possible reflected and shadowed losses, distributed in a 360-degree pattern within the cavity or plenum space.
- G. Intensity: UV-C lamp system modeling shall be included in the submittal and must contain necessary

calculations to demonstrate a minimum of [6 W/sq. ft. (64.6 W/sq. m)][4 W/sq. ft. (43.0 W/sq. m)] of coil surface area to achieve a minimum of 100 microwatts/sq. cm equally distributed on the target surface as recommended by ASHRAE.

- H. Housing Installation: Power supply housing can be installed inside or outside air-handling units or plenums.
- I. UV Lamp Installation: Mount UV lamp to irradiate surfaces, as well as the available line of sight airstream, through proper lamp placement, and incident angle reflection.
- J. Safety: Comply with requirements in UL 1995, "Standard of Safety for Heating and Cooling Equipment." Provide mechanical interlock switch on access panels and doors to UV lamp systems, or within view of UV lamp systems, to ensure that UV-C lamp systems will be de-energized when these accesses are opened. Warning signs and labels are specified in Section 230553 "Identification for HVAC Piping and Equipment."
- K. Signage: Comply with requirements in UL 1995 "Heating and Cooling Equipment." Mark access panels and doors to UV-C lamp systems with warning signs stating, "WARNING: UV LIGHT SOURCE" and "DISCONNECT POWER BEFORE SERVICING." Warning signs and labels are specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.3 INSTALLATION OF ANTIMICROBIAL UV-C LAMP SYSTEMS FOR LARGE AIR-HANDLING UNITS

- A. Size and rate supports for UV-C lamp system weight.
- B. Maintain UV lamp position after cleaning and relamping.
- C. Provide support for UV-C lamp system without causing deflection of air-handling unit casing.
- D. Provide vertical supports on interior air-handling unit surfaces for UV-C lamp system.
- E. UV-C lamp system mounting devices shall be capable of supporting a horizontal force of 100 percent of system weight, and a vertical force of 400 percent of system weight.
- F. Equipment supports are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.4 ELECTRIC CONNECTIONS

- A. Provide electrical power and service disconnects to products requiring electrical connections.
- B. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- C. Comply with requirements for service disconnects in Section 262816 "Enclosed Switches and Circuit Breakers."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 IDENTIFICATION

- A. Identify UV-C lamp systems with equipment labels. Comply with requirements for equipment labels specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Operational Test: After installing UV-C lamp systems, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Safety Interlock: Confirm proper operation of safety interlock power switches on access panels and doors.
- C. UV-C lamp systems and components will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.8 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.

3.9 ADJUSTING

- A. After installation, adjust UV-C lamp systems and supports to maximize exposure to surfaces, before energizing system.

3.10 CLEANING

- A. Wipe lamps clean using manufacturers' recommended cleaning methods and materials.

3.11 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain UV-C lamp systems.



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

END OF SECTION 23 05 66 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 05 66 00	23 05 00 00a	Coatings for HVAC



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 05 93 00 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section Includes:

1. TAB of Air Systems:
 - a. Constant-volume air systems.
 - b. Dual-duct systems.
 - c. Variable-air-volume systems.
 - d. Multizone systems.
 - e. Induction-unit systems.
2. TAB of Hydronic Piping Systems:
 - a. Constant-flow hydronic systems.
 - b. Variable-flow hydronic systems.
 - c. Primary-secondary hydronic systems.
3. TAB of fuel oil systems for HVAC.
4. TAB of steam and condensate piping systems.
5. TAB of equipment.
6. TAB of existing HVAC systems and equipment.
7. Procedures for exhaust hoods.
8. Sound tests.
9. Vibration tests.
10. Duct-leakage tests verification.
11. Pipe-leakage tests verification.
12. UFAD plenum-leakage tests verification.
13. HVAC-controls verification.
14. Smoke-control system tests.
15. Stair-pressurization system tests.
16. Elevator-pressurization system tests.

B. Related Requirements:

1. Section 220593 "Testing, Adjusting, and Balancing for Plumbing" for TAB of plumbing systems and equipment.

1.2 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. FFT: Fast Fourier transform.
- C. INCE: Institute of Noise Control Engineering
- D. NC: Noise criteria.

- E. NEBB: National Environmental Balancing Bureau.
- F. RC: Room criteria.
- G. TAB: Testing, adjusting, and balancing.
- H. TABB: Testing, Adjusting, and Balancing Bureau.
- I. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- J. TDH: Total dynamic head.
- K. UFAD: Underfloor air distribution.

1.3 PREINSTALLATION MEETINGS

- A. TAB Conference: Conduct a TAB conference at **[Project site]<Insert location>** after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of **[14]<Insert number>** days' advance notice of scheduled meeting time and location.
 - 1. Minimum Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Requirements for coordination and cooperation of trades and subcontractors.
 - d. Proposed procedures for documentation and communication flow.

1.4 ACTION SUBMITTALS

- A. Sustainable Design Submittals:
 - 1. Air-Balance Report: Documentation indicating that the Work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
 - 2. TAB Report: Documentation indicating that the Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."
 - 3. HVAC Flush Report: Documentation indicating that building HVAC system flush complies with Green Globes v1.4, Section 3.1.2.4 - "IAQ during Construction."

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within **[30][45][60][90]<Insert number>** days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within **[30][60][90]<Insert number>** days of Contractor's Notice to Proceed, provide a summary report of the examination review required in "Examination" Article, if issues are discovered that may preclude the proper testing and balancing of the systems. Submit a summary report of the examination review required in "Examination" Article.
- C. Strategies and Procedures Plan: Within **[30][60][90]<Insert number>** days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.

- D. System Readiness Checklists: Within [30][60][90]<Insert number> days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article, to be used and filled out by systems installers verifying that systems are ready for TAB.
- E. Certified TAB Reports: Within [14][21][30]<Insert number> days of completion of testing and balancing work.
 - 1. Submit one copy of the final TAB report to the design professional of record's firm. Provide [five]<Insert number> additional copies to Contractor.
- F. Sample Report Forms: For each specified report.
- G. Instrument Calibration Reports: Include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.
 - 5. Dates of calibration and calibration interval.

1.6 QUALITY ASSURANCE

- A. TAB Specialist Firm's Qualifications, Certified by AABC:
 - 1. TAB Field Supervisor: Employee of the TAB specialist firm and certified by AABC.
 - 2. TAB Technician: Employee of the TAB specialist firm and certified by AABC.
- B. TAB Specialist Firm's Qualifications: Certified by [NEBB][or][TABB] .
 - 1. TAB Certified Professional: Employee of the TAB specialist firm and certified by [NEBB][or][TABB] .
 - 2. TAB Technician: Employee of the TAB specialist firm and certified by [NEBB][or][TABB] .
 - 3. TAB specialist firm is to be independent, third-party, and unaffiliated with Contractor.
- C. Sound and Vibration Specialists: **[NEBB-certified Sound and Vibration Technician][TABB-certified Sound and Vibration Technician][INCE Board-certified professional][Vibration Institute Category I Certified Vibration Analyst][Vibration Institute Category II Certified Vibration Analyst][Vibration Institute Category III Certified Vibration Analyst][Vibration Institute Category IV Certified Vibration Analyst][or][licensed professional engineer who specializes in acoustical engineering]<Insert sound and vibration certification> .**
- D. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- E. ASHRAE 111 Compliance: For testing and balancing of HVAC systems.
 - 1. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- F. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.3.3 - "System Balancing."
- G. Code and Authorities Having Jurisdiction Compliance: Furnish TAB services that comply with governing codes and requirements of authorities having jurisdiction.

1.7 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TAB SPECIALIST FIRMS

- A. Subject to compliance with requirements, **[engage one of the following][available TAB specialist firm that may be engaged include, but are not limited to, the following] :**
 - 1. **<Insert, in separate subparagraphs, TAB specialist firm's name> .**

3.2 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in system designs that may preclude proper TAB of systems and equipment. Submit Contract Documents Examination Report summary of findings.
- B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Note the locations of devices that are not accessible for TAB.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- E. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, clean and permanent filters are installed, and equipment with functioning controls is ready for operation.
- F. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning as indicated on Drawings or in the Specifications.
- G. Verify, with installation Contractor, that startup strainer screens have been replaced with permanent screens and that all strainers have been cleaned.
- H. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.
- I. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- J. Examine air vents to verify that air has been removed from all hydronic systems.
- K. Observe demonstration of operating safety interlocks and controls on HVAC equipment.

- L. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

3.3 PREPARATION

- A. Prepare a TAB plan that includes the following:
 - 1. Equipment and systems to be tested.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Sample forms with specific identification for all equipment.
- B. Prepare system-readiness checklists of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 - 1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.
 - i. Windows and doors are installed and are in normal operating positions.
 - j. Note location of balancing devices that are inaccessible.
 - k. UFAD-Specific Requirements:
 - 1) Verify that raised access panels are installed.
 - 2) Verify that air plenums are free of debris.
 - 3) Verify that air plenum dividers are installed.
 - 4) Follow procedures to measure Category 1 and 2 leakage in AABC's "National Standards to Total System Balance."
 - 2. Hydronics:
 - a. Verify leakage and pressure tests on water distribution systems have been completed in accordance with applicable code and authorities having jurisdiction.
 - b. Piping is complete with terminals installed.
 - c. Water treatment is complete.
 - d. Systems are flushed, filled, and air purged.
 - e. Verify that pressure at highest point in the system is a minimum of **[5 psig (34.5 kPa)]<Insert minimum pressure>**.
 - f. Strainers are pulled and cleaned.
 - g. Control valves are functioning in accordance with the controls sequence of operation.
 - h. Shutoff and balance valves have been verified to be 100 percent open.
 - i. Pumps are started and proper rotation is verified.
 - j. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
 - k. Variable-frequency controllers' startup is complete, and safeties are verified.
 - l. Note location of balancing devices that are inaccessible.



3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system in accordance with the procedures contained in **[AABC's "National Standards for Total System Balance"]****[ASHRAE 111]****[NEBB's "Procedural Standard for Testing, Adjusting and Balancing of Environmental Systems"]****[SMACNA's "HVAC Systems - Testing, Adjusting & Balancing"]****[and]****[SMACNA's "TAB Procedural Guide"]** and in this Section.
- B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. Installing Contractor to Perform the Following:
 - a. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - b. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
 - c. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
 - d. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in **[inch-pound (IP)]****[and]** units.
- E. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.5 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

- A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:
 - 1. Motors.
 - 2. Pumps.
 - 3. Fans and ventilators.
 - 4. Air curtains.
 - 5. Terminal units.
 - 6. Commercial kitchen hoods.
 - 7. Boilers.
 - 8. Deaerators.
 - 9. Furnaces.
 - 10. Radiant heaters.
 - 11. Unit heaters.
 - 12. Solar collectors.
 - 13. Heat exchangers.
 - 14. Condensing units.
 - 15. Condensers.
 - 16. Water chillers.

17. Cooling towers.
18. Energy-recovery units.
19. Air-handling units.
20. Heating and ventilating units.
21. Rooftop air-conditioning units.
22. Heating-only makeup air units.
23. Dedicated outdoor-air units.
24. Packaged air conditioners.
25. Self-contained air conditioners.
26. Computer-room air conditioners.
27. Split-system air conditioners.
28. Variable-refrigerant-flow systems.
29. Heat pumps.
30. Valance heating and cooling units.
31. Chilled beams.
32. Coils.
33. Fan coil units.
34. Unit ventilators.
35. Radiators.
36. Convectors.
37. Finned-tube radiation heaters.
38. Radiant-heating **[cables][piping][and][panels]** .
39. Humidifiers.
40. Dehumidification units.

3.6 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain approved submittals and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare single-line schematic diagram of systems or color-coded HVAC drawings for the purpose of identifying HVAC components, including each air terminal unit and each air diffuser, register, and grille.
- C. For variable-air-volume systems, develop a plan to simulate diversity and include in TAB plan.
- D. Determine suitable locations in main and branch ducts for accurate duct-airflow measurements.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
- F. Verify that motor controllers are equipped with properly sized thermal protection.

3.7 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.

2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet.
 - b. Measure static pressure directly at the fan inlet.
 - c. Measure static pressure differential across each component that makes up the air-handling system.
 - d. Apply artificial loading of filters to simulate a dirty filter pressure drop condition at the time static pressures are measured.
 3. Obtain approval from **[Architect][Owner][Construction Manager][Commissioning Authority]** for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 4. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
 2. Adjust submain and branch duct volume dampers for specified airflow.
 3. Re-measure each submain and branch duct after all volume dampers have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 2. Measure inlets' and outlets' airflow. Apply correction factors as applicable for each size and style of air device.
 3. Adjust each inlet and outlet for specified airflow.
 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design range. Readjust to within design tolerance if necessary.
 2. Re-measure and confirm that total airflow is within design.
 3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
 4. Traverse the supply airflow in full airside economizer mode. Observe the mixed air plenum pressure as compared to normal operation: return air dampers open and minimum outside air varying to 100 percent outside air dampers fully open and return air dampers fully closed. Mixed air pressure is to remain constant plus/minus 20 percent or, otherwise, damper/fan adjustments will be required.
 5. Mark all final settings.
 6. Measure and record all operating data.
 7. Record final fan-performance data.

3.8 PROCEDURES FOR DUAL-DUCT SYSTEMS

- A. Adjust the dual-duct systems as follows:
1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge. On systems with separate hot-deck and cold-deck fans, verify the location

- of the sensor on each deck.
2. Verify that the system is under static pressure control.
 3. Verify that the high static pressure safety is set below the maximum static pressure rating of the ductwork.
 4. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point, so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses. Perform this procedure for the hot deck and for the cold deck.
 5. Calibrate and balance each terminal unit's hot deck and cold deck for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for full cooling. Some controllers require starting with minimum set point. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factors as required for design cold-deck maximum airflow and hot-deck minimum airflow. Record calibration factors.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for full heating.
 - e. Measure airflow and adjust calibration factors as required for design cold-deck minimum airflow and hot-deck maximum airflow. Record calibration factors. If no minimum calibration is available, note any deviation from design airflow. Verify that the airflow when damper is closed is zero.
 6. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Set terminals for maximum airflow. If system design includes diversity (cooling coil or fan), adjust terminals for maximum and minimum airflow so that connected total matches cooling coil or fan selection and simulates actual load in the building. In systems with separate hot-deck and cold-deck fans, diversity consideration applies to each individual fan.
 - c. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
 7. Measure the fan(s) static pressures as follows:
 - a. Measure static pressure directly at the fan outlet.
 - b. Measure static pressure directly at the fan inlet.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
 8. Set final return and outside airflow to the fan(s) while operating at maximum return airflow and minimum outdoor airflow.
 - a. Balance the return-air ducts and inlets.
 - b. Verify that all terminal units are delivering design airflow under system maximum flow.
 9. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point, to maintain the optimum system static pressure. Record set point and give to controls Contractor.
 10. Verify final system conditions as follows:

- a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to deliver within design value tolerances if necessary.
- b. Re-measure and confirm that total airflow is within design value tolerances.
- c. Re-measure final fan operating data, speed, volts, amps, and static profile.
- d. Mark final settings.
- e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
- f. Verify tracking between supply and return fans via air flow measurements in the supply, return, relief, and outside air flow paths.

11. Record final fan-performance data.

3.9 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.
 - e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - f. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
5. Set the air terminal units to maximum airflow. Record the following for each air terminal unit:
 - a. Design maximum airflow.
 - b. Tested and balanced maximum airflow.
 - c. BAS system maximum airflow.
 - d. BAS damper position.
 - e. Adjust the air-handling unit fan airflow until one air terminal unit damper position is 85 percent open.
 - f. Record the duct static pressure sensor and set the fan static pressure controller to the recorded static pressure sensor.
 - g. Record the fan operating Hz.
 - h. If the system has filters that will exceed **0.5 inch wg (125 Pa)** pressure differential when dirty, simulate the dirty filter pressure drop and repeat all the above recorded readings ("a" through "g"), noting dirty filter condition.
 - i. With N+1, isolate one fan and repeat all the above recorded readings ("a" through "g"),

- noting N+1 condition.
 - j. Each condition must have all air-handling-unit data recorded, including static pressure profiles at outdoor air, return air, relief air, total supply air, supply air fan suction and discharge, return air fan suction and discharge, and relief air fan suction and discharge.
6. Measure fan static pressures as follows:
- a. Measure static pressure directly at the fan outlet.
 - b. Measure static pressure directly at the fan inlet.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
- a. Balance the return-air ducts and inlets.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point, to maintain the optimum system static pressure. Record set point and give to controls Contractor.
9. Verify final system conditions as follows:
- a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.
 - c. Re-measure final fan operating data, speed, volts, amps, and static profile.
 - d. Mark final settings.
 - e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
 - f. Verify tracking between supply and return fans.

3.10 PROCEDURES FOR MULTIZONE SYSTEMS

- A. Position the unit's automatic zone dampers for maximum flow through the cooling coil.
 - B. The procedures for multizone systems will utilize the zone balancing dampers to achieve the indicated airflow within the zone.
 - C. After balancing, place the unit's automatic zone dampers for maximum heating flow. Retest zone airflows and record any variances.
 - D. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
1. Measure total airflow.
- a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor air conditions.
 - b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
2. Measure fan static pressures as follows:

- a. Measure static pressure directly at the fan outlet.
 - b. Measure static pressure directly at the fan inlet.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 3. Review record Drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 4. Obtain approval from **[Architect][Owner][Construction Manager][Commissioning Authority]** for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- E. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
 2. Adjust submain and branch duct volume dampers for specified airflow.
 3. Re-measure each submain and branch duct after all have been adjusted.
- F. Adjust air inlets and outlets for each space to indicated airflows.
1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 2. Measure inlet and outlet airflow.
 3. Adjust each inlet and outlet for specified airflow.
 4. Re-measure each inlet and outlet after they have been adjusted.
- G. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 2. Re-measure and confirm that total airflow is within design.
 3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
 4. Mark all final settings.
 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
 6. Measure and record all operating data.
 7. Record final fan-performance data.
- 3.11 PROCEDURES FOR INDUCTION-UNIT SYSTEMS
- A. Balance primary-air risers by measuring static pressure at the nozzles of the top and bottom units of each riser, to determine which risers must be throttled. Adjust risers to indicated airflow within specified tolerances.
- B. Adjust each induction unit.
- C. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
1. Measure total airflow.

- a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet.
 - b. Measure static pressure directly at the fan inlet.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 3. Review record Drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 4. Obtain approval from **[Architect][Owner][Construction Manager][Commissioning Authority]** for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
 - D. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 1. Measure airflow of submain and branch ducts.
 2. Adjust submain and branch duct volume dampers for specified airflow.
 3. Re-measure each submain and branch duct after all have been adjusted.
 - E. Balance airflow to each induction unit by measuring the nozzle pressure and comparing it to the manufacturer's published data for nozzle pressure versus cfm. Adjust the unit's inlet damper to achieve the required nozzle pressure for design cfm.
 - F. Verify final system conditions.
 1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 2. Re-measure and confirm that total airflow is within design.
 3. Re-measure all final fan operating data, speeds, volts, amps, and static profile.
 4. Mark all final settings.
 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
 6. Measure and record all operating data.
 7. Record final fan-performance data.
- 3.12 GENERAL PROCEDURES FOR HYDRONIC PIPING SYSTEMS
- A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Cross-check the summation of required coil and equipment flow rates with pump design flow rate.
 - B. Prepare single-line schematic diagram of systems for the purpose of identifying HVAC components.

- C. Prepare schematic diagrams of systems' record Drawings piping layouts.
- D. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
 - 1. Check expansion tank for proper setting.
 - 2. Check highest vent for adequate pressure.
 - 3. Check flow-control valves for proper position.
 - 4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
 - 5. Verify that motor controllers are equipped with properly sized thermal protection.
 - 6. Check that air has been purged from the system.
- E. Measure and record upstream and downstream pressure of each piece of equipment.
- F. Measure and record upstream and downstream pressure of pressure-reducing valves.
- G. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
 - 1. Check settings and operation of each safety valve. Record settings.

3.13 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Adjust pumps to deliver total design flow.
 - 1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 - 2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gauge heights.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling. Before pump impellers are trimmed, verify if any future load requirements and close throttling valve, noting the position.
 - 3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition. While operating pump(s) at maximum flow conditions, verify pump(s) are operating below nameplate and are non-overloading through full range of operation.
- B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
 2. Adjust main and branch balance valves for design flow.
 3. Re-measure each main and branch after all have been adjusted.
- C. Adjust flow-measuring devices installed at terminals for each space to design water flows.
1. Measure flow at terminals.
 2. Adjust each terminal to design flow.
 3. Re-measure each terminal after it is adjusted.
 4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 5. Perform temperature tests after flows have been balanced.
 6. Use coil pressure drop to determine flow if no flow meter measurement exists.
 7. Use temperatures and flows to calculate actual capacity on each coil and heat exchanger.
- D. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
 2. Perform temperature tests after flows have been verified.
- E. For systems without pressure-independent valves or flow-measuring devices at terminals:
1. Measure and balance coils by either coil pressure drop or by capacity method calculation.
 2. Use coil pressure drop to determine flow.
 3. Perform temperature tests after flows have been verified.
- F. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
 2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 3. Mark final settings.
- G. Verify that memory stops have been set. Add and mark all balanced valve positions for valves that do not have memory stops.

3.14 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.
- B. Adjust the variable-flow hydronic system as follows:
1. Verify that the pressure-differential sensor(s) is located as indicated.
 2. Determine whether there is diversity in the system.
- C. For systems with no flow diversity:
1. Adjust pumps to deliver total design flow with variable-frequency drive(s) set to 60 Hz.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

- b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gauge heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - c. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.
2. Monitor motor performance during procedures, and do not operate motor in an overloaded condition. While operating pump(s) at maximum flow conditions, verify pump(s) are operating below nameplate and are non-overloading through full range of operation.
 3. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow by using manually balancing valve.
 - c. Re-measure each main and branch after all have been adjusted.
 4. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
 5. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
 6. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
 7. Prior to verifying final system conditions, determine the system pressure-differential set point(s).
 8. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, verify the pressure at the controller sensor and set the controller to the measured pressure at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions. Reverify the pressure at the controller.
 9. Mark final settings and verify that all memory stops have been set.
 10. Verify final system conditions as follows:
 - a. Re-measure and confirm that total flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, static pressure profile,

- and variable-frequency drive Hz.
 - c. Mark final settings.
- D. For systems with flow diversity:
 - 1. Determine diversity factor.
 - 2. Simulate system diversity by closing required number of control valves located closest to the pump(s).
 - 3. Adjust pumps to deliver total design flow.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gauge heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - c. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.
 - 4. Monitor motor performance during procedures, and do not operate motor in an overloaded condition. While operating pump(s) at maximum flow conditions, verify pump(s) are operating below nameplate and are non-overloading through full range of operation.
 - 5. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
 - 6. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
 - 7. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure, and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.

8. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
9. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
10. Prior to verifying final system conditions, determine system pressure-differential set point(s).
11. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
12. Mark final settings and verify that memory stops have been set.
13. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
 - c. Mark final settings.

3.15 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

- A. Balance the primary circuit flow first.
- B. Balance the secondary circuits after the primary circuits are complete.
- C. Adjust pumps to deliver total design flow.
 1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gauge heights.
 - d. Verify pump impeller size by measuring TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.
 - e. With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.
 3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition. While operating pump(s) at maximum flow conditions, verify pump(s) are operating below nameplate and are non-overloading through full range of operation.
- D. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
 2. Adjust main and branch balance valves for design flow.
 3. Re-measure each main and branch after all have been adjusted.
- E. Adjust flow-measuring devices installed at terminals for each space to design water flows.
1. Measure flow at terminals.
 2. Adjust each terminal to design flow.
 3. Re-measure each terminal after it is adjusted.
 4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 5. Perform temperature tests after flows have been balanced.
- F. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
 2. Perform temperature tests after flows have been balanced.
- G. For systems without pressure-independent valves or flow-measuring devices at terminals:
1. Measure and balance coils by either coil pressure drop or temperature method.
 2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- H. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
 2. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
 3. Mark final settings.
- I. Verify that memory stops have been set.

3.16 PROCEDURES FOR STEAM AND CONDENSATE PIPING SYSTEMS

- A. Measure and record upstream and downstream pressure of each piece of equipment.
- B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.
- C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
- D. Check settings and operation of each safety valve. Record settings.
- E. Verify the operation of each steam trap.

3.17 PROCEDURES FOR STEAM-TO-WATER HEAT EXCHANGERS

- A. Measure, adjust, and record water flow to within specified tolerances.
- B. Measure and record inlet and outlet water temperatures.
- C. Measure and record inlet steam pressure and condensate outlet pressure.
- D. Check and record settings and operation of safety and relief valves.

3.18 PROCEDURES FOR WATER-TO-WATER HEAT EXCHANGERS

- A. Measure, adjust, and record water flow to within specified tolerances.
- B. Measure and record inlet and outlet water temperatures.
- C. Measure and record pressure drop.
- D. Check and record settings and operation of safety and relief valves.

3.19 PROCEDURES FOR MOTORS

- A. Motors: [1/2]<Insert value> hp and larger; test at final balanced conditions and record the following data:
 - 1. Manufacturer's name, model number, and serial number.
 - 2. Motor horsepower rating.
 - 3. Motor rpm.
 - 4. Phase and hertz.
 - 5. Nameplate and measured voltage, each phase.
 - 6. Nameplate and measured amperage, each phase.
 - 7. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation. Verify and report Hz at maximum and minimum flows.

3.20 PROCEDURES FOR WATER CHILLERS

- A. Air-Cooled Chillers: Balance water flow through each evaporator to within specified tolerances of indicated flow, with all pumps operating. With only one chiller operating in a multiple-chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 - 1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
 - 2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer or via chiller control panel readout.
 - 3. Power factor if factory-installed instrumentation is furnished for measuring kilowatts or via chiller control panel readout.
 - 4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts or via chiller control panel readout.
 - 5. Capacity: Calculate in **tons (kilowatts)** of cooling via chiller control panel readout.
 - 6. Verify condenser-fan rotation and record fan and motor data, including number of fans and entering- and leaving-air temperatures.
- B. Water-Cooled Chillers: Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow, with all pumps operating. With only one chiller operating in a multiple-chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 - 1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
 - 2. Condenser-water entering and leaving temperatures, pressure drop, and water flow.
 - 3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer or via chiller control panel readout.

4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts or via chiller control panel readout.
5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts or via chiller control panel readout.
6. Capacity: Calculate in **tons (kilowatts)** of cooling via chiller control panel readout.

3.21 PROCEDURES FOR COOLING TOWERS

- A. Performance Testing: Comply with [CTI ATC-105][Cooling tower AABC performance test in AABC's "National Standards for Total System Balance"] [SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing," Ch. 15 "Hydronic System TAB Procedures"]<Insert test procedure> .
- B. Closed-Circuit Cooling Towers: Balance total condenser-water flows to towers and cells. Measure and record the following data:
 1. Unit number.
 2. Manufacturer.
 3. Model number.
 4. Serial number.
 5. Number of cells.
 6. Capacity in cooling tons.
 7. Design and actual fan rpm.
 8. Flow rate in **gpm (L/s)**.
 9. Condenser-water flow to each cell of the cooling tower.
 10. Pressure drop through each cell.
 11. Entering- and leaving-water temperatures.
 12. Wet- and dry-bulb temperatures of entering air.
 13. Wet- and dry-bulb temperatures of leaving air.
 14. Barometric pressure, wind speed, and wind direction.
 15. Condenser-water flow rate recirculating through the cooling tower.
 16. Cooling-tower spray pump discharge pressure.
 17. Condenser-water flow through bypass.
 18. Makeup-water flow rate.
 19. Makeup-water temperature.
 20. Fan, motor, and motor controller operating data.
 21. Cooling-tower spray pump and motor operating data.
 22. Heater operating data.
- C. Open-Circuit Cooling Towers: Balance total condenser-water flows to towers and cells. Measure and record the following data:
 1. Condenser-water flow to each cell of the cooling tower.
 2. Pressure at each inlet connection.
 3. Entering- and leaving-water temperatures.
 4. Range (cooling tower inlet water temperature minus cooling tower outlet water temperature).
 5. Makeup-water flow rate.
 6. Makeup-water temperature.
 7. Wet- and dry-bulb temperatures of entering air.
 8. Wet- and dry-bulb temperatures of leaving air.
 9. Approach (ambient wet bulb minus leaving water temperature).
 10. Barometric pressure, wind speed, and wind direction.
 11. Fan, motor, and motor controller operating data.
 12. Heater operating data.

3.22 PROCEDURES FOR AIR-COOLED CONDENSING UNITS

- A. Verify proper rotation of fan(s).
- B. Measure and record entering- and leaving-air temperatures.
- C. Measure and record operating data of compressor(s), fan(s), and motors.

3.23 PROCEDURES FOR AIR-COOLED CONDENSERS

- A. Verify proper rotation of fan(s).
- B. Measure and record entering- and leaving-air temperatures.
- C. Measure and record operating data of fan(s) and motor(s).

3.24 PROCEDURES FOR BOILERS

- A. Hydronic Boilers:
 - 1. Measure and record entering- and leaving-water temperatures.
 - 2. Measure and record water flow.
 - 3. Measure and record pressure drop.
 - 4. Record relief valve(s) pressure setting.
 - 5. Fan, motor, and motor controller operating data.
- B. Steam Boilers:
 - 1. Measure and record entering-water temperature.
 - 2. Measure and record feedwater flow.
 - 3. Record leaving-steam pressure and temperature from installed gauges.
 - 4. Record relief valve(s) pressure setting.
 - 5. Fan, motor, and motor controller operating data.
- C. Boilers with Flue Gas Economizers:
 - 1. Measure and record entering- and leaving-water temperature.
 - 2. Measure and record water flow rate.
 - 3. Measure and record water pressure drop.
- D. Gas-Fired Boilers:
 - 1. Test and document proper operation of emergency gas shut-down switch.

3.25 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each hydronic coil:
 - 1. Entering- and leaving-water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.

4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.
8. Use coil pressure drop to determine flow if no flow meter measurement exists.
9. Use temperatures and flows to calculate actual capacity on each coil and heat-transfer coils.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Air pressure drop.
5. Voltage and amperage input of each phase at full load.
6. Record full load kW.
7. Record fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Air pressure drop.
4. Record inlet steam pressure from installed gauge.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.

3.26 PROCEDURES FOR EXHAUST HOODS

- A. Room Pressure: Measure and record room pressure with respect to atmosphere and adjacent space with hoods in room initially not operating and then with hoods operating.
- B. Makeup Air: Systems supplying source of makeup air to hoods are to be in operation during testing and balancing of exhaust hoods.
1. Measure and record temperature of makeup air entering hood. If hood makeup air is from multiple sources having different temperatures, measure and record the airflow and temperatures of each source and calculate the weighted average temperature.
 2. Use simulated smoke to observe supply air-distribution air patterns in vicinity of hoods. Consult with hood manufacturer and report conditions that have a detrimental effect on intended capture, containment, and other attributes effecting proper operation.
- C. Rooms with Multiple Hoods: Test each hood separately, one at a time, and repeat tests with all hoods intended to operate simultaneously by design.
- D. Canopy Hoods: Measure and record the following:
1. Airflow by duct traverse where duct distribution will allow accurate measurement, and calculate hood average face velocity.
 2. Measure velocity across hood face and calculate hood airflow.

- a. Clearly indicate the direction of flow at each point of measurement.
 - b. Measure velocity across opening on not less than [12-inch (300-mm)]<Insert dimension> centers. Record velocity at each measurement, and calculate average velocity.
3. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Observe and report performance. Make adjustments to achieve optimum results.

E. Laboratory Fume Hoods:

1. See Section 115313 "Laboratory Fume Hoods" for testing requirements in "Performance Requirements" Article.
2. Measure and record the following:
 - a. Pressure drop across hood.
 - b. Airflow by duct traverse where duct distribution will allow accurate measurement, and calculate hood average face velocity. If hood is connected to exhaust duct distribution through an exhaust device with integral airflow measurement, that reading may be used in lieu of a duct traverse.
 - c. Face velocity across open hood face and calculate hood airflow.
 - 1) Clearly indicate the direction of flow at each point of measurement.
 - 2) Measure face velocity across opening, using imaginary grid pattern and calibrated fixed anemometer readings per grid in accordance with ASHRAE 110 airflow face velocity measurement procedure.
 - d. ASHRAE 110 Capture and Containment Testing:
 - 1) With room and laboratory fume hood operating at design conditions, perform an "as-installed" performance test of the laboratory fume hood in accordance with the following ASHRAE 110 tests:
 - a) Flow visualization procedure.
 - b) Tracer gas test procedure.

F. Kitchen Grease Hoods:

1. Testing Procedure:
 - a. Type 1: Measure and record pressure drop and face velocity of hood filters and slots in accordance with hood manufacturer's written instructions. Consult hood manufacturer to determine hood airflow using recorded information.
 - b. Type 2: Measure and record airflow by duct traverse.
 - c. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Observe and report performance. Make adjustments to achieve optimum results.
2. Testing: Testing procedure is to be in accordance with AABC's "National Standards for Total System Balance."

G. Authorities Having Jurisdiction Tests: Conduct additional tests required by authorities having jurisdiction.

3.27 SOUND TESTS

- A. After systems are balanced and Substantial Completion, with all systems operating at normal conditions and with all spaces completed and finished for occupancy, measure and record sound levels at **[five][10][15]<Insert number>** locations as designated by Architect. All building mechanical, electrical, and plumbing equipment, which may affect sound readings, must be operational.
- B. Sound-Level Testing Meter Instrumentation - Minimum Requirements:
1. Portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
 2. Capable of showing fluctuations at minimum and maximum levels and measuring the equivalent continuous sound pressure level (Leq).
 3. Capable of using one-third octave band filters to measure frequencies from 31.5 Hz to 8000 Hz.
 4. Accuracy of plus/minus two decibels.
 5. Current NIST-traceable annual calibration. Calibrate instruments prior to taking measurements and after taking measurements each day of use.
- C. Test Procedures - Indoors:
1. Measure and record sound levels at the following rooms: **<Insert list of room numbers and names where sound testing is required>** .
 2. For each room/location tested, select a measurement location that has the greatest anticipated sound level. If testing multiple locations for each room type, select at least one location that is near and at least one location that is remote from the predominant sound source.
 3. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
 4. Equipment is to be operating at design values.
 5. Sound-testing firm is to have access to controls hardware, software, and onsite technical support at no cost to the sound-testing firm. The installing contractors are to provide a controlled, steady-state environment (flow, pressure, control, and temperature) during the duration of sound testing.
 6. Use a microphone suitable for the type of noise levels measured that is compatible with meter.
 7. At each measurement location, record a set of background sound pressure levels, with fast time constant and minimum time duration of 60 seconds, in the eight unweighted octave bands **[63 Hz to 8000 Hz (NC)][31.5 Hz to 4000 Hz (RC)]** with the equipment off.
 8. At each measurement location, record a set of sound pressure levels, with fast time constant and minimum time duration of 60 seconds, in the eight unweighted octave bands **[63 Hz to 8000 Hz (NC)][31.5 Hz to 4000 Hz (RC)]** with the equipment operating.
 9. Take readings no closer than **36 inches (900 mm)** from a wall or from the operating equipment and approximately **48 inches (1200 mm)** from the floor, with the meter held or mounted on a tripod.
- D. Test Procedures - Outdoors:
1. Make outdoor measurements at **[property lines]<Insert location(s)>** .
 2. Make measurements when background noise sources are at a minimum or when they do not affect equipment sound levels such as when the background noise levels are at least 10 dB less than the equipment noise levels.
 3. Use microphone suitable for the type of noise levels measured that is compatible with the meter and as recommended by the sound-level meter manufacturer.
 4. Provide a windshield for outside measurements whenever wind speed is greater than **5 mph (8 Km/h)**.
- E. Reporting:
1. The final report is to contain the following information at a minimum:

- a. Report Title Page: Page indicating Project name, names of Project Architect, engineer, HVAC Contractor, and sound measurement firm with names, addresses, and telephone numbers.
- b. Report Certification Page: Page indicating Project name, sound measurement firm name, name of individual performing measurements, and all required sound technician certifications.
- c. Table of Contents: Identify report sections and total number of pages in each section.
- d. Report Summary/Remarks: Narrative description of system setup conditions, results, and deficiencies.
- e. Instrument Calibration Section: List of instruments to be used to verify the reported data, containing the name/type of each instrument, manufacturer, model number, serial number, calibration date and dates of use, and NIST-traceable calibration certificates.
- f. Sound Measurement Data Sheets: Record sound measurements on sound measurement report forms, indicating the decibel levels measured for both "background" and "building system operating" readings. Record each tested location on a separate NC or RC chart. Record the following information on the forms:
 - 1) Date and time of test.
 - 2) Equipment Operational Parameters: Speed and frequency at time of measurements.
 - 3) Indoor Measurements: Space location within the building, including floor level and room space number.
 - 4) Outdoor Measurements: Location identifier such as location relative to equipment, building, or property line.
 - 5) Indicate where measurements meet or exceed design criteria.

3.28 VIBRATION TESTS

- A. After systems are balanced and Substantially Completion, measure and record vibration levels on equipment having motor horsepower equal to or greater than [3]<Insert number>[for pumps and fans],[5]<Insert number>[for chillers and compressors] .
- B. Instrumentation:
 1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
 2. Meter is to automatically identify engineering units, frequency resolution, filter bandwidth, amplitude, and frequency scale values.
 3. Meter is to be able to measure machine vibration displacement in mils of deflection; velocity in inches per second (meters/sec); and acceleration in G's (or g-force), inches per second squared (G's, meters per second squared).
 4. Calibration of instrument and transducer must be NIST traceable and must be current during the time period measurements are being made. Vibration instruments and transducers must have NIST-traceable calibration every 12 months. Verify calibration date is current for vibration meter before taking readings.
- C. Pretest Procedures:
 1. Before any vibration measurements are made, confirm that the following items have been completed and any deficiencies found are reported to the appropriate parties for remedy:
 - a. Verify that all vibration isolators are installed in accordance with respective manufacturer's written instructions.
 - b. Verify that piping, duct, and conduit penetrations through mechanical equipment room envelope are sealed, and that there is no rigid contact with building structure.

- c. Inspect steel isolation bases for cracked welds and bending/twisting of steel members.
- d. Inspect concrete isolation bases for cracked concrete. Check isolator retainer brackets to be sure they are not loose. Concrete base must be flat and true level.
- e. Examine elastomeric isolators for cracks in the rubber and for loose bonds between the rubber and the steel plates and other steel components. Verify clearance is provided between bolts and the side of bolt holes to prevent short circuiting.
- f. Examine steel spring isolators for loose or missing bolts, nuts, and lock washers. Verify springs are not overloaded or underloaded, completely collapsed, or cocked. Verify rubber or glass-fiber pad between bottom steel spring plate and the concrete/supporting structure is in place.
- g. Inspect isolators that have seismic restraint devices to make sure that all shims have been removed and supportive nuts have been properly adjusted to allow for free floating of the isolated system.
- h. Verify that seismic restraints are not preventing proper functioning of vibration isolation function.
- i. Verify space under isolated bases are clean and free of debris that could cause short-circuiting.
- j. Verify that shipping bolts associated with spring isolators have been removed so that they do not short-circuit the system.
- k. Verify flexible piping, hoses, and expansion joint types, lengths, and locations are as specified.
- l. Verify that electrical and control connections do not restrain movement of the vibration-isolated equipment.
- m. Verify flexible connections between fans and ductwork "bellow" as designed when fans are operating.
- n. Verify that hanger isolator rods are free of misalignment and not in rigid contact with the hanger housing.

D. Test Procedures:

- 1. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not adversely influence measurements of equipment being tested.
- 2. Observe if there is equipment in the building that might interfere with testing. Note the equipment to the Construction Manager and request resolution before testing begins.
- 3. Take measurements when exterior vibration sources, such as trains, roadway traffic, adjacent construction activities, and the like, are at a minimum level.
- 4. Attach and secure vibration transducer in accordance with the most current edition of **[NEBB's "Procedural Standards for Measurement of Sound and Vibration"]<Insert reference document>** .
- 5. Measure and record vibration levels **[in at least 1.25 Hz (75 rpm) increments over a minimum frequency range of 5 to 1000 Hz (300 to 60,000 rpm)]<Insert increment requirements>** .
- 6. Measure and record acceleration and/or velocity and/or displacement readings on equipment; bearing and equipment base in the vertical, horizontal, and axial planes; or as per-contract specifications, where measurements can be performed safely and where measurement locations are accessible.

a. Pumps:

- 1) Pump Bearing: Drive end and opposite end.
- 2) Motor Bearing: Drive end and opposite end.
- 3) Equipment Base: Top and side, within **6 inches (152 mm)** of one isolator.
- 4) Building: Floor adjacent to pump/motor, within **6 inches (152 mm)** of one isolator; vertical axis only.

b. Fans and HVAC Equipment with Fans:

- 1) Fan Bearing: Drive end and opposite end.
- 2) Motor Bearing: Drive end and opposite end.
- 3) Equipment Base: Top and side, within **6 inches (152 mm)** of one isolator; vertical axis only.

c. Chillers and HVAC Equipment with Compressors:

- 1) Compressor Bearing: Drive end and opposite end.
- 2) Motor Bearing: Drive end and opposite end.
- 3) Equipment Base: Top and side, within **6 inches (152 mm)** of one isolator.
- 4) Building: Floor adjacent to pump/motor, within **6 inches (152 mm)** of one isolator; vertical axis only.

7. FFT Analyzer Settings:

- a. Windowing: Hanning.
- b. Averages: At least two.
- c. Frequency Range: **5 to 1000 Hz (300 to 60,000 rpm)**.
- d. Frequency Resolution: At least **1.25 Hz (75 rpm)**.
- e. Line of Resolution: At least 800.
- f. Detection: Peak, peak-to-peak, or RMS.
- g. Averaging: Exponential.

E. Reporting:

1. Vibration Measurement Report Forms:

- a. For each measurement location, record vibration measurements on appropriate test forms, showing the following information:

- 1) Date of test.
- 2) Equipment designation, location, motor horsepower, and equipment operational parameters (speed/frequency) at time of test.
- 3) Measured acceleration, **[in units of G's (g-force), inches/seconds squared (meters/seconds squared)]<Insert units of measure>** .
- 4) Measured displacement, **[in units of inches, mils (millimeters)]<Insert units of measure>** .
- 5) Vibration level plot of vibration amplitude versus frequency for each measurement location.
- 6) Verify vibration amplitude level plot versus frequency for each measurement location.

2. Verify actual vibration against vibration limits. Follow the **[General Machinery Vibration Severity Chart][or][Vibration Acceleration General Severity Chart]** from **[ASHRAE Handbook - "HVAC Applications," Ch. "Noise and Vibration Control"]****[NEBB's "Procedural Standard for Measurement of Sound and Vibration"]****[or][AABC's "National Standards for Total System Balance"]** . Acceptable levels of vibration are normally "smooth" to "good."
3. Include General Machinery Vibration Severity Chart with all conditions plotted.
4. Test each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.
5. Include horizontal-vertical-axial measurements for tests.

3.29 DUCT-LEAKAGE TESTS VERIFICATION

- A. Witness the duct-leakage testing performed by Installer.
- B. Duct-leakage testing is to be performed by a technician certified by **[AABC][NEBB][TABB][or]<Insert other equivalent approved agency>** in accordance with SMACNA's "HVAC Air Duct Leakage Test Manual" and IAPMO's Uniform Mechanical Code, "Duct Leakage Tests" Article.
- C. Verify that proper test methods are used and that leakage rates are within specified limits.
- D. Report deficiencies observed.

3.30 PIPE-LEAKAGE TESTS VERIFICATION

- A. Witness the pipe pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified limits.
- C. Report deficiencies observed.

3.31 UFAD PLENUM-LEAKAGE TESTS VERIFICATION

- A. UFAD Plenum-Leakage Testing Performed by TAB Specialist:
 - 1. Verify that leakage rates are within specified limits for Category 1 and for Category 2 leakage utilizing **[technology similar to door fan test rigs]<Insert testing method>** .
 - 2. Report results and deficiencies observed.
- B. UFAD Plenum-Leakage Testing Witnessed by TAB Specialist:
 - 1. Witness the UFAD plenum pressure testing performed by Installer.
 - 2. Verify that proper test methods are used and that leakage rates are within specified limits for Category 1 and for Category 2 leakage.
 - 3. Report deficiencies observed.

3.32 HVAC-CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 - 1. Work to ensure the system is operating within the design limitations and gain a mutual understanding of intended controls performance.
 - 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 - 3. Verify that controllers are calibrated and function as intended.
 - 4. Verify that controller set points are as indicated.
 - 5. Verify the operation of lockout or interlock systems.
 - 6. Verify the operation of valve and damper actuators.
 - 7. Verify that controlled devices are properly installed and connected to correct controller.
 - 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
 - 9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.33 PROCEDURES FOR STAIR-PRESSURIZATION SYSTEM TESTS

- A. Before testing, observe each pressurized stair enclosure to verify construction is complete. Verify the following:
 - 1. Walls and ceiling are free of unintended openings and are capable of achieving a pressure boundary.
 - 2. Firestopping and sealants are installed.
 - 3. Doors, door closers, and door gaskets are installed and adjusted.
 - 4. If applicable, window installation is complete.
 - 5. Stair-pressurization fans and associated controls are installed and functioning properly.
 - 6. Stair-pressurization duct distribution and air outlets are installed.
 - 7. Life-safety dampers (smoke or combination fire and smoke) are installed and functioning properly.
- B. Measure and record barometric pressure, wind speed and direction, outdoor-air temperature, and relative humidity on each test day.
- C. Test each stair enclosure as a single system. If multiple fans serve a single stair enclosure, operate fans as intended by the design.
- D. Initial Air Balance: Open doors to floors where indicated by design and measure, adjust, and record the airflow of each of the following:
 - 1. Stair-pressurization fan. For ducted systems, measure fan airflow by duct Pitot-tube traverse unless duct distribution does not permit accurate readings.
 - 2. Air outlet supplying stair enclosure.
 - 3. Adjust enclosure total airflow to achieve design pressurization.
 - 4. Adjust method of stair enclosure pressure relief to prevent overpressurization.
- E. Pressurization Test and Adjustments:
 - 1. After air balancing is complete, perform stair enclosure-pressurization tests.
 - 2. Establish a consistent procedure for recording data throughout entire test.
 - 3. Use stair side of doors as pressure reference point.
 - a. Positive Pressure: Floor side of door higher than stair side.
 - b. Negative Pressure: Floor side of door lower than stair side.
 - 4. With HVAC systems and stair-pressurization systems off, measure and record the following:
 - a. Pressure difference across each stair enclosure door, with all doors in the stair enclosure closed.
 - b. Force necessary to open each door, using a spring-type scale.
 - c. Adjustment needed to achieve design pressurization of enclosure total airflow.
 - d. Adjustment needed to method of stair enclosure pressure relief, to prevent overpressurization.
 - 5. With HVAC systems operating in normal mode and stair-pressurization systems off, measure and record the following:

- a. Pressure difference across each stair enclosure door, with all doors in the stair enclosure closed.
 - b. Force necessary to open each door, using a spring-type scale.
 - c. Adjustment needed to achieve design pressurization of enclosure total airflow.
 - d. Adjustment needed to method of stair enclosure pressure relief, to prevent overpressurization.
 6. With HVAC systems and stair-pressurization system operating simultaneously, perform the following:
 - a. Place HVAC systems in normal operating mode, including equipment not used to implement smoke control, such as air-handling units, exhaust fans, and similar equipment.
 - b. Measure and record pressure difference across each stair enclosure door, with all doors in stair enclosure closed.
 - c. Use a spring scale to measure and record the force needed to open all stair enclosure doors.
 - d. Adjust enclosure total airflow to achieve design pressurization.
 - e. Adjust method of stair enclosure pressure relief to prevent overpressurization.
 - f. Additional Tests for Designs with Open Doors:
 - 1) With exit door to outdoors in open position, measure and record pressure difference across each of the remaining closed stair enclosure doors.
 - 2) Open additional doors (up to the number indicated by design) one at a time, and measure and record pressure difference across each remaining closed stair enclosure door after the opening of each additional door.
 - 3) For each different test condition, measure and record the direction and velocity through each of the open doors by a traverse of every [1 sq. ft. (0.093 sq. m)]<Insert requirement> grid of door opening.
 - 4) For each different test condition, calculate average of door velocity measurements. Compare average velocity to design and governing code requirements.
 - 5) Adjust enclosure total airflow to achieve design pressurization.
 - 6) Adjust method of stair enclosure pressure relief to prevent overpressurization.
 7. Repeat pressurization tests with the smoke-control systems and HVAC systems operating.
 8. Criteria for Acceptance:
 - a. Compliance with design requirements.
 - b. Compliance with code requirements.
 - c. Compliance with additional requirements required by authorities having jurisdiction.
- F. Operational Tests:
1. Check proper activation of stair-pressurization system(s) in response to all means of activation, both automatic and manual.
 2. Verify that each initiating occurrence produces the proper system response under each of the following modes of operation:
 - a. Normal.
 - b. Alarm.
 - c. Manual override.
 - d. Return to normal.
 3. Verify smoke detector at pressurization fan de-energizes fan and closes isolation damper when smoke detector is activated and in alarm.
 4. If standby power is provided for pressurization systems, test to verify pressurization systems operate while on both normal and standby power.

5. Check operation in accordance with design indicated.

G. Authority Having Jurisdiction Tests: Conduct additional tests required by authorities having jurisdiction.

H. Report: Prepare and submit a complete report of observations, measurements, and deficiencies. Include names and contact information of individuals conducting tests and of individuals witnessing tests.

3.34 PROCEDURES FOR ELEVATOR-PRESSURIZATION SYSTEM TESTS

A. Before testing, observe each pressurized elevator enclosure to verify construction is complete. Verify the following:

1. Walls and ceiling are free of unintended openings and are capable of achieving a pressure boundary.
2. Firestopping and sealants are installed.
3. Doors are installed and adjusted. Elevator car doors are recalled to the default recall floor, and elevator car doors on recall floor are open.
4. If applicable, window installation is complete.
5. Pressurization fans and associated controls are installed and functioning properly.
6. Pressurization duct distribution and air outlets are installed.
7. Life-safety dampers (smoke or combination fire and smoke) are installed and functioning properly.

B. Measure and record barometric pressure, wind speed and direction, outdoor-air temperature, and relative humidity on each test day.

C. Test each elevator enclosure as a single system. If multiple fans serve a single elevator enclosure, operate fans as intended by the design.

D. Initial Air Balance: Open elevator car doors to recall floor indicated by design, and measure, adjust, and record the airflow of each:

1. Pressurization fan. For ducted systems, measure fan airflow by duct pitot-tube traverse unless duct distribution does not permit accurate readings.
2. Air outlet supplying elevator enclosure.
3. Adjustment needed to achieve design pressurization of enclosure total airflow.
4. Adjustment to method of elevator enclosure pressure relief, to prevent overpressurization.

E. Pressurization Tests and Adjustments:

1. After air balancing is complete, perform elevator enclosure pressurization tests.
2. Establish a consistent procedure for recording data throughout entire test.
3. Use elevator car side of doors as pressure reference point.
 - a. Positive Pressure: Floor side of door higher than elevator car side.
 - b. Negative Pressure: Floor side of door lower than elevator car side.
4. With HVAC systems and elevator-pressurization systems off, measure and record the following:
 - a. Pressure difference across each elevator enclosure door, with all doors in the elevator enclosure closed.
 - b. Adjustment needed to achieve design pressurization of enclosure total airflow.
 - c. Adjustment needed to method of stair enclosure pressure relief, to prevent

overpressurization.

5. With HVAC systems operating in normal mode and elevator pressurization systems off, measure and record the following:
 - a. Pressure difference across each elevator enclosure door, with all doors in the elevator enclosure closed.
 - b. Adjustment needed to achieve design pressurization of enclosure total airflow.
 - c. Adjustment needed to method of stair enclosure pressure relief, to prevent overpressurization.
6. With HVAC systems and elevator pressurization system operating simultaneously, perform the following:
 - a. Place HVAC systems in normal operating mode, including equipment not used to implement smoke control, such as air-handling units, exhaust fans, and similar equipment.
 - b. Measure and record pressure difference across each stair enclosure door, with all doors in stair enclosure closed.
 - c. Adjust enclosure total airflow to achieve design pressurization.
 - d. Adjust method of elevator enclosure pressure relief to prevent overpressurization.
7. Repeat pressurization tests with smoke-control systems and HVAC systems operating.
8. Criteria for Acceptance:
 - a. Compliance with design requirements.
 - b. Compliance with code requirements.
 - c. Compliance with additional requirements of authorities having jurisdiction.

F. Operational Tests:

1. Check proper activation of elevator-pressurization system(s) in response to all means of activation, both automatic and manual.
2. Verify that each initiating occurrence produces the proper system response under each of the following modes of operation:
 - a. Normal.
 - b. Alarm.
 - c. Manual override.
 - d. Return to normal.
3. Verify smoke detector at pressurization fan de-energizes fan and closes isolation damper when smoke detector is activated and in alarm.
4. If standby power is provided for pressurization systems, test to verify pressurization systems operate while on both normal and standby power.
5. Check operation in accordance with design indicated.

G. Authority Having Jurisdiction Tests: Conduct additional tests required by authorities having jurisdiction.

H. Report: Prepare and submit a complete report of observations, measurements, and deficiencies. Include names and contact information of individuals conducting tests and of individuals witnessing tests.

3.35 PROCEDURES FOR SMOKE-CONTROL SYSTEM TESTS

- A.** Before testing smoke-control systems, review design documents to understand operating requirements

and design intent:

1. Review boundaries of each smoke zone.
 2. Review location, size, and operating characteristics of equipment, such as smoke and fire smoke dampers.
 3. Review sequence of operation, smoke-control matrix, operating status of equipment, and position of smoke and fire dampers for each smoke zone alarm condition.
 4. Review location and type of alarm detection used to initiate smoke control for each smoke zone.
 5. Review other smoke-control system attributes not listed but required for code compliance and acceptance by authorities having jurisdiction.
- B. Before testing smoke-control systems, verify that construction is complete and verify the integrity of each smoke-control zone boundary.
1. Verify that windows, doors, walls, ceilings, and floors (six-sided boundary) are closed and that applicable safing, gasket, and firestops and sealants are installed.
 2. Report deficiencies and postpone testing until after the reported deficiencies are corrected.
- C. Measure and record barometric pressure, wind speed and direction, outdoor-air temperature, and relative humidity on each test day.
- D. Measure, adjust, and record airflow of each smoke-control system, with all fans that are a part of system operating as intended by the design.
1. Measure, adjust, and record the airflow of each fan. For ducted systems, measure fan airflow by duct Pitot-tube traverse.
 2. Measure, adjust, and record the airflow of each exhaust inlet and supply outlet.
 3. Measure, adjust, and record airflow in main and branch ducts.
- E. Smoke Control by Pressurization: After air balancing is complete, perform the following pressurization testing for each smoke-control zone in the system designed for isolation by using pressurization boundaries:
1. Verify the boundaries of each smoke-control zone.
 2. With the HVAC systems in their normal mode of operation and smoke control not operating, measure and record the pressure difference across each smoke-control zone. Make measurements after closing doors that separate the zones. Make one measurement across each door. Clearly indicate the high- and low-pressure side of each door.
 3. With the system operating in the smoke-control mode and with each separate zone in the smoke-control system activated, perform the following:
 - a. Measure and record the pressure difference across each door that separates the smoke zone from adjacent zones.
 - 1) Make measurements with doors that separate the smoke zone from the other zones closed.
 - 2) Clearly indicate the high- and low-pressure side of the door.
 - 3) Doors that have a tendency to open slightly due to the pressure difference should have one pressure measurement made while held closed and another measurement made with the door open.
 - b. Continue to activate each separate smoke zone within each smoke-control system and make pressure-difference measurements.
 - c. After testing a smoke zone's smoke-control system, deactivate the HVAC systems involved and return them to their normal operating mode before activating another zone's smoke-

- control system.
 - d. Verify that controls necessary to prevent excessive pressure differences are functional and operating within design set points and limits.
- F. Smoke-Control Systems for Atriums and Other Large-Volume Spaces: After air balancing is complete, perform the following testing for each smoke-control system serving atriums and other large-volume spaces:
 - 1. Verify and document the boundaries served by each smoke-control system.
 - 2. Identify and document closed doors, open doors, and other boundary openings to be left open to adjacent areas and that are to be protected by airflow alone.
 - 3. With the HVAC systems in their normal mode of operation and smoke-control systems not operating, measure and record the following:
 - a. Pressure difference across each door that separates the smoke-zone from adjacent zones.
 - b. Velocity for each point in traverse across each boundary opening:
 - 1) Clearly indicate the direction of flow.
 - 2) Measure velocity across opening on **[12-inch (300-mm)]<Insert dimension>** centers using a vane anemometer. Calculate and report airflow.
 - 4. With system operating in the smoke-control mode, measure and record the following:
 - a. Pressure difference across each door that separates the smoke zone from adjacent zones.
 - b. Velocity for each point in traverse across each opening:
 - 1) Clearly indicate the direction of flow.
 - 2) Measure velocity across opening on **[12-inch (300-mm)]<Insert dimension>** centers using a vane anemometer. Calculate and report airflow.
 - 5. Verify system operation and make adjustments to achieve design pressure differences and air velocities within design set points and upper operating limits.
- G. Operational Tests: As described in the sequences of operation and in the smoke-control matrix.
 - 1. Check the proper activation of each zone of each smoke-control system in response to all means of activation, both automatic and manual.
 - 2. Check automatic activation in response to fire alarm signals received from the building's fire alarm system. Initiate a separate alarm for each means of activation to ensure that the proper operation of the correct zone of each smoke-control system occurs.
 - 3. Check and record proper operation of fans, dampers, and related equipment for each separate zone of each smoke-control system:
 - a. Zone in which a smoke-control system automatically activates.
 - b. Type of signal that activates smoke-control system, such as sprinkler flow or smoke detector.
 - c. Smoke zone(s) where maximum mechanical exhaust to the outside is implemented and no supply air is provided.
 - d. Positive-pressure smoke-control zone(s) where maximum air supply is implemented and no exhaust to the outside is provided.
 - e. Fan(s) "ON" as required to implement the smoke-control system. Multiple- or variable-speed fans should be further noted to verify that the intended control configuration is achieved.
 - f. Fan(s) "OFF" as required to implement the smoke-control system.
 - g. Damper(s) "OPEN" or at an adjustable position where maximum airflow must be achieved.
 - h. Damper(s) "CLOSED" where no airflow should take place.

- i. Auxiliary functions to achieve the smoke-control system configuration, such as changes or override of normal operating pressure and temperature-control set points.
- j. If standby power is provided for the smoke-control system, test to verify that the system functions while operating under both normal and standby power.
- k. Check operation in accordance with design indicated.

H. Authority Having Jurisdiction Tests: Conduct additional tests required by authorities having jurisdiction. [**Unless required by authorities having jurisdiction, perform testing without the use of smoke or products that simulate smoke.**]

I. Report: Prepare and submit a complete report of observations, measurements, and deficiencies. Include names and contact information of individuals conducting tests and of individuals witnessing tests.

3.36 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

- 1. Measure and record the operating speed, airflow, and static pressure of each fan and equipment with fan(s).
- 2. Measure and record flows, temperatures, and pressures of each piece of equipment in each hydronic system. Compare the values to design or nameplate information, where information is available.
- 3. Measure motor voltage and amperage. Compare the values to motor nameplate information.
- 4. Check the condition of filters.
- 5. Check the condition of coils.
- 6. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. TAB after Construction: Before performing testing and balancing of renovated existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished in accordance with renovation scope indicated by Contract Documents. Verify the following:

- 1. New filters are installed.
- 2. Coils are clean and fins combed.
- 3. Drain pans are clean.
- 4. Fans are clean.
- 5. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

- 1. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan speed and the face velocity of filters and coils.
- 2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
- 3. Balance each air outlet.

3.37 TOLERANCES

A. Set HVAC system's airflow rates and water-flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: **[Plus or minus 10 percent][Plus 10 percent or minus 5 percent]<Insert value>** . If design value is less than **100 cfm (47 L/s)**, flow rate is within **10 cfm (4.7 L/s)**.
 2. Air Outlets and Inlets: **[Plus or minus 10 percent][Plus 10 percent or minus 5 percent]<Insert value>** . If design value is less than **100 cfm (47 L/s)**, flow rate is within **10 cfm (4.7 L/s)**.
 3. Heating-Water Flow Rate: **[Plus or minus 5 percent][Plus or minus 10 percent][Plus 10 percent or minus 5 percent]<Insert value>** . If design value is less than **10 gpm (0.63 L/s)**, flow rate is within 10 percent.
 4. Chilled-Water Flow Rate: **[Plus or minus 5 percent][Plus or minus 10 percent][Plus 10 percent or minus 5 percent]<Insert value>** . If design value is less than **10 gpm (0.63 L/s)**, flow rate is within 10 percent.
 5. Condenser-Water Flow Rate: **[Plus or minus 5 percent][Plus or minus 10 percent][Plus 10 percent or minus 5 percent]<Insert value>** .
- B. Maintaining pressure relationships as designed is to have priority over the tolerances specified above. If the above tolerances change the relative positive or negative airflow from/into the space, tolerances are to be adjusted so as to keep the relative positive cfm or negative cfm from/into the space a constant cfm differential.

3.38 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.
- B. Status Reports: Prepare **[weekly][biweekly][monthly]<Insert time interval>** progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.39 FINAL TESTING AND BALANCING REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 2. Include a list of instruments used for procedures, along with proof of calibration.
 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
1. Pump curves.
 2. Fan curves.
 3. Manufacturers' test data.
 4. Field test reports prepared by system and equipment installers.
 5. Other information relative to equipment performance; do not include Shop Drawings and product data.
- C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.

2. Name and address of the TAB specialist firm and technician.
 3. Project name.
 4. Project location.
 5. Project Architect's name, firm, and address.
 6. Project engineer's name, firm, and address.
 7. Project Contractor's name, firm, and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents, including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fan performance forms, including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Heating coil, dry-bulb conditions.
 - e. Face and bypass damper settings at coils.
 - f. Fan drive settings, including settings and percentage of maximum pitch diameter.
 - g. **[Variable-frequency controller][Inlet vane]** settings for variable-air-volume systems.
 - h. Settings for pressure controller(s).
 - i. Other system operating conditions that affect performance.
 16. Test conditions for pump performance forms, including the following:
 - a. Variable-frequency controller settings for variable-flow hydronic systems.
 - b. Settings for pressure controller(s).
 - c. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units, include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.

- d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in **inches (mm)**, and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in **inches (mm)**.
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
2. Motor Data:
- a. Motor make and frame type and size.
 - b. Horsepower and speed.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in **inches (mm)**, and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in **inches (mm)**.
3. Test Data (Indicated and Actual Values):
- a. Total airflow rate in **cfm (L/s)**.
 - b. Total system static pressure in **inches wg (Pa)**.
 - c. Fan speed.
 - d. Inlet and discharge static pressure in **inches wg (Pa)**.
 - e. For each filter bank, filter static-pressure differential in **inches wg (Pa)**.
 - f. Preheat-coil static-pressure differential in **inches wg (Pa)**.
 - g. Cooling-coil static-pressure differential in **inches wg (Pa)**.
 - h. Heating-coil static-pressure differential in **inches wg (Pa)**.
 - i. List for each internal component with pressure-drop, static-pressure differential in **inches wg (Pa)**.
 - j. Outdoor airflow in **cfm (L/s)**.
 - k. Return airflow in **cfm (L/s)**.
 - l. Outdoor-air damper position.
 - m. Return-air damper position.
 - n. Vortex damper position.
- F. Apparatus-Coil Test Reports:
1. Coil Data:
- a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in **ins per inch (mm) o.c.**
 - f. Make and model number.
 - g. Face area in **sq. ft. (sq. m)**.
 - h. Tube size in **NPS (DN)**.
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
- a. Airflow rate in **cfm (L/s)**.
 - b. Average face velocity in **fpm (m/s)**.
 - c. Air pressure drop in **inches wg (Pa)**.

- d. Outdoor-air, wet- and dry-bulb temperatures in **deg F (deg C)**.
 - e. Return-air, wet- and dry-bulb temperatures in **deg F (deg C)**.
 - f. Entering-air, wet- and dry-bulb temperatures in **deg F (deg C)**.
 - g. Leaving-air, wet- and dry-bulb temperatures in **deg F (deg C)**.
 - h. Water-flow rate in **gpm (L/s)**.
 - i. Water pressure differential in **feet of head or psig (kPa)**.
 - j. Entering-water temperature in **deg F (deg C)**.
 - k. Leaving-water temperature in **deg F (deg C)**.
 - l. Recorded inlet steam pressure in **psig (kPa)**, as read from installed gauge.
- G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
- 1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Fuel type in input data.
 - g. Motor horsepower and speed.
 - h. Motor volts, phase, and hertz.
 - i. Motor full-load amperage and service factor.
 - j. Sheave make, size in **inches (mm)**, and bore.
 - k. Center-to-center dimensions of sheave and amount of adjustments in **inches (mm)**.
 - 2. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in **cfm (L/s)**.
 - b. Entering-air temperature in **deg F (deg C)**.
 - c. Leaving-air temperature in **deg F (deg C)**.
 - d. Air temperature differential in **deg F (deg C)**.
 - e. Entering-air static pressure in **inches wg (Pa)**.
 - f. Leaving-air static pressure in **inches wg (Pa)**.
 - g. Air static-pressure differential in **inches wg (Pa)**.
 - h. Motor voltage at each connection.
 - i. Motor amperage for each phase.
- H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
- 1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Coil identification.
 - d. Capacity in **Btu/h (kW)**.
 - e. Number of stages.
 - f. Connected volts, phase, and hertz.
 - g. Rated amperage.
 - h. Airflow rate in **cfm (L/s)**.
 - i. Face area in **sq. ft. (sq. m)**.
 - j. Minimum face velocity in **fpm (m/s)**.

2. Test Data (Indicated and Actual Values):
 - a. Heat output in **Btu/h (kW)**.
 - b. Airflow rate in **cfm (L/s)**.
 - c. Air velocity in **fpm (m/s)**.
 - d. Entering-air temperature in **deg F (deg C)**.
 - e. Leaving-air temperature in **deg F (deg C)**.
 - f. Voltage at each connection.
 - g. Amperage for each phase.
- I. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in **inches (mm)**, and bore.
 - h. Center-to-center dimensions of sheave and amount of adjustments in **inches (mm)**.
 2. Motor Data:
 - a. Motor make and frame type and size.
 - b. Horsepower and speed.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in **inches (mm)**, and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in **inches (mm)**.
 - g. Number, make, and size of belts.
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in **cfm (L/s)**.
 - b. Total system static pressure in **inches wg (Pa)**.
 - c. Fan speed.
 - d. Discharge static pressure in **inches wg (Pa)**.
 - e. Suction static pressure in **inches wg (Pa)**.
- J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 1. Report Data:
 - a. System fan and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in **deg F (deg C)**.
 - d. Duct static pressure in **inches wg (Pa)**.
 - e. Duct size in **inches (mm)**.
 - f. Duct area in **sq. ft. (sq. m)**.
 - g. Indicated airflow rate in **cfm (L/s)**.
 - h. Indicated velocity in **fpm (m/s)**.
 - i. Actual airflow rate in **cfm (L/s)**.
 - j. Actual average velocity in **fpm (m/s)**.

- k. Barometric pressure in **psig (Pa)**.
- K. Air-Terminal-Device Reports:
 - 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in **sq. ft. (sq. m)**.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in **cfm (L/s)**.
 - b. Air velocity in **fpm (m/s)**.
 - c. Preliminary airflow rate as needed in **cfm (L/s)**.
 - d. Preliminary velocity as needed in **fpm (m/s)**.
 - e. Final airflow rate in **cfm (L/s)**.
 - f. Final velocity in **fpm (m/s)**.
 - g. Space temperature in **deg F (deg C)**.
- L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 - 1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in **cfm (L/s)**.
 - b. Entering-water temperature in **deg F (deg C)**.
 - c. Leaving-water temperature in **deg F (deg C)**.
 - d. Water pressure drop in **feet of head or psig (kPa)**.
 - e. Entering-air temperature in **deg F (deg C)**.
 - f. Leaving-air temperature in **deg F (deg C)**.
- M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model number and serial number.

- f. Water flow rate in **gpm (L/s)**.
- g. Water pressure differential in **feet of head or psig (kPa)**.
- h. Required net positive suction head in **feet of head or psig (kPa)**.
- i. Pump speed.
- j. Impeller diameter in **inches (mm)**.
- k. Motor make and frame size.
- l. Motor horsepower and rpm.
- m. Voltage at each connection.
- n. Amperage for each phase.
- o. Full-load amperage and service factor.
- p. Seal type.

2. Test Data (Indicated and Actual Values):

- a. Static head in **feet of head or psig (kPa)**.
- b. Pump shutoff pressure in **feet of head or psig (kPa)**.
- c. Actual impeller size in **inches (mm)**.
- d. Full-open flow rate in **gpm (L/s)**.
- e. Full-open pressure in **feet of head or psig (kPa)**.
- f. Final discharge pressure in **feet of head or psig (kPa)**.
- g. Final suction pressure in **feet of head or psig (kPa)**.
- h. Final total pressure in **feet of head or psig (kPa)**.
- i. Final water flow rate in **gpm (L/s)**.
- j. Voltage at each connection.
- k. Amperage for each phase.

N. Instrument Calibration Reports:

1. Report Data:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration and interval.

3.40 VERIFICATION OF TAB REPORT

- A. The TAB specialist firm's test and balance technician is to conduct the final verification in the presence of **[Architect][Owner][Construction Manager][Commissioning Authority]** .
- B. **[Architect][Owner][Construction Manager][Commissioning Authority]** are to randomly select measurements, documented in the final report, to be rechecked. Rechecking is to be limited to the lesser of either **[10]<Insert number>** percent of the total measurements recorded or the extent of measurements that can be accomplished in **[a normal 8-hour business day]<Insert value>** .
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements are to be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than **[10][20]<Insert number>** percent of the total measurements checked during the final inspection, the TAB are to be considered incomplete and are to be rejected.
- E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:



1. TAB specialists are to recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes are to be tracked to show changes made to previous report.
2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

3.41 REVERIFICATION

- A. TAB specialist firm technicians are to recheck all measurements and make adjustments as required to complete the balancing. Revise the final report and balancing device settings to include all changes; resubmit final report and request a second verification.
- B. If the second verification also fails, [Owner][Architect] may contact [AABC headquarters regarding the AABC National Performance Guaranty][TABB Quality Assurance Program, Customer Complaint Procedures]<Insert guaranty organization> .

3.42 ADDITIONAL TESTS

- A. Within [90]<Insert number> days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 05 93 00	02 41 19 00	Selective Demolition
23 05 93 00	23 05 00 00a	Coatings for HVAC



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 07 13 00 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Glass-fiber duct insulation.
2. Mineral wool duct insulation.
3. Flexible elastomeric duct insulation.
4. Polyolefin duct insulation.
5. Fire-rated duct insulation systems.
6. Insulation adhesives.
7. Insulation mastics and coatings.
8. Insulation sealants.
9. Field-applied insulation jackets.
10. Field-applied fabric-reinforcing mesh for insulation.
11. Field-applied cloths for insulation.
12. Vapor-retarder tapes.
13. Insulation securements.
14. Insulation corner angles.

B. Related Requirements:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct insulation liners.

1.2 ACTION SUBMITTALS

- A. Product Data:** For each type of specified product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Shop Drawings:** Include plans, elevations, sections, details, and attachments to other work.
1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 2. Detail insulation application at elbows, fittings, dampers, specialties, and flanges for each type of insulation.
 3. Detail application of field-applied jackets.
 4. Detail application at linkages of control devices.
- C. Samples:** For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
1. Sheet Form Insulation Materials: **12 inches (300 mm)** square.
 2. Sheet Jacket Materials: **12 inches (300 mm)** square.
 3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating percentage of postconsumer and preconsumer recycled content and cost.
2. Product Data: For adhesives, indicating VOC content.
3. Product Data: For coatings, indicating VOC content.
4. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.
5. Product Data: For sealants, indicating VOC content.

1.3 INFORMATIONAL SUBMITTALS

- A. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- B. Field Quality Control Reports: For specified tests and inspections.
- C. Qualification Statements: For Installer.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program [, **certified by the Department of Labor, Bureau of Apprenticeship and Training**] .

1.5 MOCKUPS

- A. Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
 1. Ductwork Mockups:
 - a. One **10-ft. (3-m)** section each of rectangular and round straight duct.
 - b. One each of a 90-degree mitered round and rectangular elbow, and one each of a 90-degree radius round and rectangular elbow.
 - c. One rectangular branch takeoff and one round branch takeoff from a rectangular duct. One round tee fitting.
 - d. One rectangular and round transition fitting.
 - e. Four support hangers for round and rectangular ductwork.
 - f. Each type of damper and specialty.
 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
 3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
 4. Obtain Architect's approval of mockups before starting insulation application.
 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.
 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.



7. Demolish and remove mockups when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation system materials are to be delivered to Project site in unopened containers. The packaging is to include name of the manufacturer, fabricator, type, description, and size [, **as well as ASTM standard designation and maximum use temperature**] .

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes, and for space required for maintenance.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 2. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 3. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 DUCT INSULATION MATERIALS, GENERAL

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are to be applied.
- B. Products are not to contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel are to have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

- D. Insulation materials for use on austenitic stainless steel are to be qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials are not to use CFC or HCFC blowing agents in the manufacturing process.

2.3 GLASS-FIBER DUCT INSULATION

A. Duct Insulation Wrap - Glass-Fiber Blanket:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
3. Description: Glass-fiber blanket duct insulation wrap consisting of glass fibers bonded with a thermosetting resin.
4. Suitable for maximum use temperature up to **450 deg F (232 deg C)** in accordance with ASTM C411.
5. Standards: ASTM C553, Type II, and ASTM C1290.
6. Without Insulation Facing: Type I.
7. Factory-Applied Insulation Facing:
 - a. FSK: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type III.
 - b. FSP: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type III.
 - c. Vinyl: White vinyl with a permeance of **1.3 perms (0.86 metric perm)** when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

B. Duct Insulation Wrap - High-Temperature, Glass-Fiber Blanket:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. [CertainTeed; SAINT-GOBAIN]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [Knauf Insulation]
 - d. [Manson Insulation Inc.]
 - e. [Owens Corning]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CertainTeed; SAINT-GOBAIN]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [Knauf Insulation]
 - d. [Manson Insulation Inc.]
 - e. [Owens Corning]
 - f. <Insert manufacturer's name>
 3. Description: High-temperature, glass-fiber blanket duct insulation wrap consisting of glass fibers bonded with a thermosetting resin.
 4. Standard: ASTM C553, Type V, suitable for maximum use temperature up to **1000 deg F (650 deg C)**.
 5. Unfaced.
- C. Duct Insulation Wrap - Glass-Fiber Board:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [CertainTeed; SAINT-GOBAIN]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [Knauf Insulation]
 - d. [Manson Insulation Inc.]
 - e. [Owens Corning]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CertainTeed; SAINT-GOBAIN]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [Knauf Insulation]
 - d. [Manson Insulation Inc.]
 - e. [Owens Corning]
 - f. <Insert manufacturer's name>
 3. Description: Glass-fiber board duct insulation wrap consisting of glass fibers bonded with a thermosetting resin.
 4. Standard: ASTM C612, Type IA or Type IB.
 5. Suitable for use temperature between **35 deg F (1.7 deg C)** and **250 deg F (121 deg C)** for jacketed and between **35 deg F (1.7 deg C)** and **450 deg F (232 deg C)** for unfaced in accordance with ASTM C411.
 6. Unfaced.



7. Factory-Applied Insulation Facing:

- a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type III.
- b. FSK: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type III.

D. Duct Insulation Wrap - High-Temperature, Glass-Fiber Board:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
3. Description: High-temperature, glass-fiber board duct insulation wrap consisting of glass fibers bonded with a thermosetting resin.
4. Standard: ASTM C612, Type III, unfaced.
5. Suitable for maximum use temperature up to **1000 deg F (650 deg C)** in accordance with ASTM C411.

E. Duct Insulation Wrap - Glass-Fiber, Pipe and Tank:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [CertainTeed; SAINT-GOBAIN]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [Knauf Insulation]
 - d. [Manson Insulation Inc.]
 - e. [Owens Corning]
 - f. <Insert manufacturer's name>
3. Description: Glass-fiber, pipe and tank insulation wrap consisting of glass fibers bonded with a thermosetting resin.
 4. Standard: ASTM C1393.
 5. Suitable for use between **35 deg F (1.7 deg C)** and **850 deg F (454 deg C)**, in accordance with ASTM C411.
 6. Semirigid board material.
 7. Factory-Applied Insulation Facings:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type III.
 - b. FSK: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type III.

2.4 MINERAL WOOL DUCT INSULATION

A. Duct Insulation Wrap - Mineral Wool Blanket:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [Owens Corning]
 - c. [ROCKWOOL]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert **manufacturer's name; product name or designation**> or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [Owens Corning]
 - c. [ROCKWOOL]
 - d. <Insert manufacturer's name>
3. Description: Mineral wool blanket duct insulation wrap consisting of basalt volcanic rock-derived fibers bonded with a thermosetting resin.
4. Standard: ASTM C553.
5. Unfaced.
6. Suitable for maximum use temperature up to **1200 deg F (650 deg C)** in accordance with ASTM C447.

B. Duct Insulation Wrap - Mineral Wool Board:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following] :

- a. [Johns Manville; a Berkshire Hathaway company]
 - b. [Owens Corning]
 - c. [ROCKWOOL]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [Owens Corning]
 - c. [ROCKWOOL]
 - d. <Insert manufacturer's name>
3. Description: Mineral wool board, duct insulation wrap consisting of basalt volcanic rock-derived fibers bonded with a thermosetting resin.
4. Standard: ASTM C612, Type III, unfaced.
5. Suitable for maximum use temperature up to **1100 deg F (600 deg C)** in accordance with ASTM C411.

C. Duct Insulation Wrap - Mineral Wool, Pipe and Tank:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [Owens Corning]
 - c. [ROCKWOOL]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [Owens Corning]
 - c. [ROCKWOOL]
 - d. <Insert manufacturer's name>
3. Description: Mineral wool, pipe and tank insulation wrap consisting of fibers bonded with a thermosetting resin.
4. Standard: ASTM C1393.
5. Suitable for maximum use temperature up to **1000 deg F (538 deg C)**, in accordance with ASTM C411.
6. Semirigid board material.
7. Factory-Applied Insulation Facings:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type III.
 - b. FSK: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type III.

2.5 FLEXIBLE ELASTOMERIC DUCT INSULATION

A. Duct Insulation Wrap - Flexible Elastomeric:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**
 - c. **[K-Flex USA]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**
 - c. **[K-Flex USA]**
 - d. **<Insert manufacturer's name>**
3. Description: Closed-cell or expanded-rubber flexible elastomeric duct insulation wrap.
4. Standard: ASTM C534/C534M, Type II for sheet materials.
5. Grade 1, suitable for use between **minus 70 deg F (minus 57 deg C)** and **plus 220 deg F (plus 104 deg C)**.

2.6 POLYOLEFIN DUCT INSULATION

A. Duct Insulation Wrap - Polyolefin:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Armacell LLC]**
 - b. **[Sekisui Voltek, LLC]**
 - c. **[Thermaxduct]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armacell LLC]**
 - b. **[Sekisui Voltek, LLC]**
 - c. **[Thermaxduct]**
 - d. **<Insert manufacturer's name>**
3. Description: Polyethylene-type of polyolefin thermal plastic duct insulation wrap.
4. Standard: ASTM C1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

2.7 FIRE-RATED DUCT INSULATION SYSTEMS

A. Duct Insulation - Fire-Rated Board:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
3. Description: Structural-grade, press-molded, xonolite calcium silicate fireproofing board insulation.
4. Standard: ASTM C656, Type II, Grade 6, suitable for operating temperatures up to **1700 deg F (927 deg C)**.
5. Fire-Rating Requirements: Insulation assembly to be tested and certified to provide a **[1][2]** -hour fire rating by an NRTL acceptable to authorities having jurisdiction.

B. Duct Insulation - Fire-Rated Blanket:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[3M Building and Construction]**
 - b. **[CertainTeed; SAINT-GOBAIN]**
 - c. **[Thermal Ceramics]**
 - d. **[Unifrax Corporation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[3M Building and Construction]**
 - b. **[CertainTeed; SAINT-GOBAIN]**
 - c. **[Thermal Ceramics]**
 - d. **[Unifrax Corporation]**
 - e. **<Insert manufacturer's name>**
3. Description: High-temperature, flexible, blanket duct insulation with FSK jacket.
4. Fire-Rating Requirements: Insulation assembly to be tested and certified to provide a **[1][2]** -hour fire rating by an NRTL acceptable to authorities having jurisdiction.
5. Factory-Applied Insulation Facing:
 - a. FSK: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with

ASTM C1136, Type II.

2.8 INSULATION ADHESIVES

- A. Materials are to be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated.
- B. Insulation Adhesive for Lagging Cloth:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Vimasco Corporation]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Vimasco Corporation]**
 - d. **<Insert manufacturer's name>**
 3. Standard: MIL-A-3316C, Class I, Grade A.
 4. Adhesives to be compatible with insulation materials, jackets, and substrates.
 5. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
 6. Service Temperature Range: **[Plus 20 to 180 deg F (Minus 6 to plus 82 deg C)][0 to plus 180 deg F (Minus 18 to plus 82 deg C)]** .
 7. Color: White.
 8. Verify adhesive is as recommended by insulation manufacturer and has a VOC content of **[50]<Insert number>** g/L or less.
- C. Insulation Adhesive for Flexible Elastomeric and Polyolefin:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**
 - c. **[Childers Brand; H. B. Fuller Construction Products]**
 - d. **[Foster Brand; H. B. Fuller]**
 - e. **[K-Flex USA]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Aeroflex USA]
- b. [Armaceil LLC]
- c. [Childers Brand; H. B. Fuller Construction Products]
- d. [Foster Brand; H. B. Fuller]
- e. [K-Flex USA]
- f. <Insert manufacturer's name>

3. Verify adhesives have a VOC content of [50]<Insert number> g/L or less.
4. Standard: MIL-A-24179A, Type II, Class I.

D. Insulation Adhesive for Glass Fiber and Mineral Wool:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. <Insert manufacturer's name>
3. Standard: MIL-A-3316C, Class 2, Grade A.
4. Adhesive: As recommended by mineral-fiber manufacturer and with a VOC content of 80 g/L or less.
5. Verify fiberglass adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).

E. Insulation Adhesive for ASJ and FSK Facings/Jackets:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]

- c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
 - 3. Description: Adhesive for bonding FSK jacket lap seams and joints.
 - 4. Standard: MIL-A-3316C, Class 2, Grade A.
 - 5. Verify adhesives have a VOC content of 80 g/L or less.
 - F. Insulation Adhesive for PVC Jackets:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Dow Consumer Solutions]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[P.I.C. Plastics, Inc.]**
 - d. **[Proto Corporation]**
 - e. **[Sekisui Voltek, LLC]**
 - f. **[Speedline Corporation]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dow Consumer Solutions]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[P.I.C. Plastics, Inc.]**
 - d. **[Proto Corporation]**
 - e. **[Sekisui Voltek, LLC]**
 - f. **[Speedline Corporation]**
 - g. **<Insert manufacturer's name>**
 - 3. Adhesive: As recommended by PVC jacket manufacturer and with a VOC content of 50 g/L or less.
 - 4. Description: PVC jacket adhesive to be compatible with and as recommended in writing in PVC jacket manufacturer's literature.
- 2.9 INSULATION MASTICS AND COATINGS
- A. Materials are to be compatible with insulation materials, jackets, and substrates.
 - 1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.
 - B. Duct Insulation Vapor-Retarder Mastic - Water Based, Indoor Use:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Aeroflex USA]**
 - b. **[Childers Brand; H. B. Fuller Construction Products]**
 - c. **[Foster Brand; H. B. Fuller]**

- d. **[Knauf Insulation]**
- e. **[Vimasco Corporation]**
- f. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Aeroflex USA]**
- b. **[Childers Brand; H. B. Fuller Construction Products]**
- c. **[Foster Brand; H. B. Fuller]**
- d. **[Knauf Insulation]**
- e. **[Vimasco Corporation]**
- f. **<Insert manufacturer's name>**

- 3. Suitable for indoor use on below-ambient services.
- 4. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
- 5. Service Temperature Range: **Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).**
- 6. Standard: MIL-PRF-19565C, Type II, for permeance requirements [, **with supplier listing on DOD QPD - Qualified Products Database**] .
- 7. Color: **[White]<Insert color>** .

C. Duct Insulation Vapor-Retarder Mastic - Solvent Based, Indoor Use:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[Childers Brand; H. B. Fuller Construction Products]**
- b. **[Foster Brand; H. B. Fuller]**
- c. **[Mon-Eco Industries, Inc.]**
- d. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Childers Brand; H. B. Fuller Construction Products]**
- b. **[Foster Brand; H. B. Fuller]**
- c. **[Mon-Eco Industries, Inc.]**
- d. **<Insert manufacturer's name>**

- 3. Description: Duct insulation vapor-retarder mastic, solvent-based, suitable for indoor use on below-ambient services.
- 4. Water-Vapor Permeance: ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
- 5. Service Temperature Range: **0 to 180 deg F (Minus 18 to plus 82 deg C).**
- 6. Color: **[White]<Insert color>** .

D. Duct Insulation Vapor-Retarder Mastic - Solvent Based, Outdoor Use:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [Aeroflex USA]
 - b. [Childers Brand; H. B. Fuller Construction Products]
 - c. [Eagle Bridges - Marathon Industries]
 - d. [Foster Brand; H. B. Fuller]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Aeroflex USA]
 - b. [Childers Brand; H. B. Fuller Construction Products]
 - c. [Eagle Bridges - Marathon Industries]
 - d. [Foster Brand; H. B. Fuller]
 - e. <Insert manufacturer's name>
3. Description: Duct insulation vapor-retarder mastic, solvent-based, suitable for outdoor use on below-ambient services.
4. Water-Vapor Permeance: ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
5. Service Temperature Range: **Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).**
6. Color: [White]<Insert color> .

E. Insulation Breather Mastic - Water Based, Indoor/Outdoor:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Eagle Bridges - Marathon Industries]
 - c. [Foster Brand; H. B. Fuller]
 - d. [Knauf Insulation]
 - e. [Mon-Eco Industries, Inc.]
 - f. [Vimasco Corporation]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Eagle Bridges - Marathon Industries]
 - c. [Foster Brand; H. B. Fuller]
 - d. [Knauf Insulation]
 - e. [Mon-Eco Industries, Inc.]
 - f. [Vimasco Corporation]
 - g. <Insert manufacturer's name>
3. Description: Duct insulation breather mastic, water-based, suitable for indoor and outdoor use on above ambient services.
4. Water-Vapor Permeance: ASTM E96/E96M, greater than **1.0 perm (0.66 metric perm)** at

- manufacturer's recommended dry film thickness.
5. Service Temperature Range: **[0 to plus 180 deg F (Minus 18 to plus 82 deg C)][Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C)]** .
 6. Color: **[White]<Insert color>** .
 7. Verify mastics comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 8. Verify mastics comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 9. Verify mastics comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.

2.10 INSULATION SEALANTS**A. Insulation Joint Sealant:**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **[Owens Corning]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **[Owens Corning]**
 - e. **<Insert manufacturer's name>**
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: **[Minus 58 to plus 176 deg F (Minus 50 to plus 80 deg C)][Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C)]** .
5. Color: White or gray.
6. Verify sealant has a VOC content of 420 g/L or less.

B. Flashing Sealant for FSK and Metal Jackets:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Eagle Bridges - Marathon Industries]**
 - c. **[Foster Brand; H. B. Fuller]**
 - d. **[Mon-Eco Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Eagle Bridges - Marathon Industries]**
 - c. **[Foster Brand; H. B. Fuller]**
 - d. **[Mon-Eco Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Sealant to be compatible with insulation materials, jackets, and substrates.
 4. Fire- and water-resistant, flexible, elastomeric sealant.
 5. Service Temperature Range: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).**
 6. Color: Aluminum.
 7. Verify sealant has a VOC content of 420 g/L or less.

C. Flashing Sealant for ASJ, PVDC, and PVC Jackets:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
3. Materials to be compatible with insulation materials, jackets, and substrates.
 4. Fire- and water-resistant, flexible, elastomeric sealant.
 5. Service Temperature Range: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).**
 6. Color: White.
 7. Verify sealant has a VOC content of 420 g/L or less.

2.11 FIELD-APPLIED INSULATION JACKETS

- A. Field-applied jackets are to comply with ASTM C921, Type I unless otherwise indicated.
- B. Insulation Jacket, Field Applied - FSK: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. Duct Insulation Jacket, Field Applied - PVC:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[P.I.C. Plastics, Inc.]**
 - c. **[Proto Corporation]**
 - d. **[Speedline Corporation]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[P.I.C. Plastics, Inc.]**
 - c. **[Proto Corporation]**
 - d. **[Speedline Corporation]**
 - e. **<Insert manufacturer's name>**
 3. Description: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C.
 4. Thickness: As indicated in "Indoor, Field-Applied Insulation Jacket Schedule" and "Outdoor, Field-Applied Insulation Jacket Schedule" articles under Part 3.
 5. Jacket: Roll stock ready for shop or field cutting and forming.
 6. Adhesive: As recommended by jacket material manufacturer.
 7. Color: **[White][Color-code jackets based on system. Color as selected by Architect]** .
- D. Duct Insulation Jacket, Field Applied - Metal:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[RPR Products, Inc.]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[RPR Products, Inc.]**
 - c. **<Insert manufacturer's name>**
 3. Jacket Material - Aluminum:
 - a. Description: **[Sheet and roll stock ready for shop or field sizing][Factory cut and rolled to size]** .
 - b. Standard: **ASTM B209 (ASTM B209M)**, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - c. Finish and Thickness: As indicated in "Indoor, Field-Applied Insulation Jacket Schedule" and "Outdoor, Field-Applied Insulation Jacket Schedule" articles under Part 3.

- d. Moisture Barrier for Indoor Applications: **[1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick polysurlyn]** .
 - e. Moisture Barrier for Outdoor Applications: **[3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick polysurlyn]** .
 - 4. Jacket Material - Stainless Steel:
 - a. Description: **[Sheet and roll stock ready for shop or field sizing][Factory cut and rolled to size]** .
 - b. Standard: ASTM A240/A240M.
 - c. Material Type, Finish, and Thickness: As indicated in "Indoor, Field-Applied Insulation Jacket Schedule" and "Outdoor, Field-Applied Insulation Jacket Schedule" articles under Part 3.
 - d. Moisture Barrier for Indoor Applications: **[1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick polysurlyn]** .
 - e. Moisture Barrier for Outdoor Applications: **[3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick polysurlyn]** .
- E. Insulation Jacket, Field Applied - Outdoor, Self Adhesive (Asphaltic):
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Foster Brand; H. B. Fuller]**
 - b. **[MFM Building Products Corp.]**
 - c. **[Polyguard Products, Inc.]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Foster Brand; H. B. Fuller]**
 - b. **[MFM Building Products Corp.]**
 - c. **[Polyguard Products, Inc.]**
 - d. **<Insert manufacturer's name>**
 - 3. Description: Self-adhesive outdoor asphaltic jacket of rubberized bituminous resin on a cross-laminated polyethylene film covered with **[white][stucco-embossed]** aluminum foil.
 - 4. Vapor Barrier/Waterproofing Membrane: **60 mils (1.5 mm)** thick.
- F. Insulation Jacket, Field Applied - Indoor/Outdoor, Self Adhesive (Non-Asphaltic):
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[3M Building and Construction]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[3M Building and Construction]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **<Insert manufacturer's name>**
3. Description:
 - a. Vapor barrier and waterproofing jacket for installation over insulation located aboveground, outdoors or indoors.
 - b. Specialized jacket to have five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive.
 - c. Outer aluminum surface coated with UV-resistant coating for protection from environmental contaminants.
4. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
5. Flame-Spread/Smoke Developed Index: 25/50 as tested in accordance with ASTM E84.
6. Aluminum Finish: **[Embossed][Smooth]** .
7. Outer Aluminum Surface: Coated with UV-resistant coating for protection from environmental contaminants.

2.12 FIELD-APPLIED FABRIC-REINFORCING MESH FOR INSULATION**A. Woven Glass-Fiber Mesh for Duct Insulation, Field Applied:**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
3. Woven glass-fiber mesh of approximately **6 oz./sq. yd. (203 g/sq. m)** with a thread count of **5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm)** for covering duct insulation.

B. Woven Polyester Mesh for Duct Insulation, Field Applied:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Vimasco Corporation]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Vimasco Corporation]**
 - d. **<Insert manufacturer's name>**
3. Description: Woven polyester mesh for covering duct and duct fittings insulation.
4. Weight: Approximately **1 oz./sq. yd. (34 g/sq. m)**.
5. Thread Count: **10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm)**.
6. Weave Type: Leno.

2.13 FIELD-APPLIED CLOTHS FOR INSULATION

A. Woven Glass-Fiber Cloth, Field Applied, for Insulation:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Alpha Associates, Inc.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alpha Associates, Inc.]**
 - b. **<Insert manufacturer's name>**
3. Description: Woven glass-fiber cloth.
4. Standard: MIL-C-20079H, Type I.
5. Weave: Plain.
6. Weight: Minimum of **8 oz./sq. yd. (271 g/sq. m)**, presized.

2.14 VAPOR-RETARDER TAPES

A. Vapor-Retarder Tape for ASJ:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Aeroflex USA]**

- c. [Avery Dennison Corporation, Specialty Tapes Division]
- d. [Ideal Tape Co., Inc., an American Biltrite Company]
- e. [Knauf Insulation]
- f. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [3M Industrial Adhesives and Tapes Division]
- b. [Aeroflex USA]
- c. [Avery Dennison Corporation, Specialty Tapes Division]
- d. [Ideal Tape Co., Inc., an American Biltrite Company]
- e. [Knauf Insulation]
- f. <Insert manufacturer's name>

- 3. Description: White vapor-retarded tape matching factory-applied jacket with acrylic adhesive.
- 4. Standard: ASTM C1136.
- 5. Width: [3 inches (75 mm)]<Insert value> .
- 6. Thickness: [11.5 mils (0.29 mm)]<Insert value> .
- 7. Adhesion: [90 ounces force/inch (1.0 N/mm)]<Insert value> in width.
- 8. Elongation: [2]<Insert value> percent.
- 9. Tensile Strength: [40 lbf/inch (7.2 N/mm)]<Insert value> in width.
- 10. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. Vapor-Retarder Tape for FSK:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [3M Industrial Adhesives and Tapes Division]
- b. [Avery Dennison Corporation, Specialty Tapes Division]
- c. [Ideal Tape Co., Inc., an American Biltrite Company]
- d. [Knauf Insulation]
- e. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [3M Industrial Adhesives and Tapes Division]
- b. [Avery Dennison Corporation, Specialty Tapes Division]
- c. [Ideal Tape Co., Inc., an American Biltrite Company]
- d. [Knauf Insulation]
- e. <Insert manufacturer's name>

- 3. Description: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
- 4. Width: [3 inches (75 mm)]<Insert value> .
- 5. Thickness: [6.5 mils (0.16 mm)]<Insert value> .
- 6. Adhesion: [90 ounces force/inch (1.0 N/mm)]<Insert value> in width.
- 7. Elongation: [2]<Insert number> percent.
- 8. Tensile Strength: [40 lbf/inch (7.2 N/mm)]<Insert value> in width.

9. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Vapor-Retarder Tape for PVC:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - c. **<Insert manufacturer's name>**
3. Description: White, vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive.
4. Suitable for indoor and outdoor applications.
5. Width: **[2 inches (50 mm)]<Insert value>** .
6. Thickness: **[6 mils (0.15 mm)]<Insert value>** .
7. Adhesion: **[64 ounces force/inch (0.7 N/mm)]<Insert value>** in width.
8. Elongation: **[500]<Insert number>** percent.
9. Tensile Strength: **[18 lbf/inch (3.3 N/mm)]<Insert value>** in width.

D. Vapor-Retarder Tape - Aluminum Foil:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Avery Dennison Corporation, Specialty Tapes Division]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **[Knauf Insulation]**
 - e. **[Sekisui Voltek, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Avery Dennison Corporation, Specialty Tapes Division]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **[Knauf Insulation]**
 - e. **[Sekisui Voltek, LLC]**
 - f. **<Insert manufacturer's name>**
3. Description: Aluminum-foil vapor-retarder tape with acrylic adhesive.
4. Width: **[2 inches (50 mm)]<Insert value>** .

5. Thickness: [3.7 mils (0.093 mm)]<Insert value> .
6. Adhesion: [100 ounces force/inch (1.1 N/mm)]<Insert value> in width.
7. Elongation: [5]<Insert number> percent.
8. Tensile Strength: [34 lbf/inch (6.2 N/mm)]<Insert value> in width.

2.15 INSULATION SECUREMENTS

A. Insulation Bands:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [RPR Products, Inc.]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [RPR Products, Inc.]
 - c. <Insert manufacturer's name>
3. Insulation Bands - Stainless Steel: ASTM A240/A240M, [Type 304][or][Type 316] ; 0.015 inch (0.38 mm) thick, [1/2 inch (13 mm)][3/4 inch (19 mm)] wide with [wing seal][or][closed seal] .
4. Insulation Bands - Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, [1/2 inch (13 mm)][3/4 inch (19 mm)] wide with [wing seal][or][closed seal] .
5. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Insulation Pins and Hangers - Capacitor-Discharge-Weld Pins:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - 1) [AGM Industries, Inc]
 - 2) [Gemco]
 - 3) [Midwest Fasteners, Inc]
 - 4) [Nelson Stud Welding]
 - 5) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [AGM Industries, Inc]

- 2) [Gemco]
 - 3) [Midwest Fasteners, Inc]
 - 4) [Nelson Stud Welding]
 - 5) <Insert manufacturer's name>
 - c. Material: [Mild steel with copper coating][Stainless steel][Aluminum] , fully annealed for capacitor-discharge welding.
 - d. Shank: [0.106 inch (2.6 mm)][0.135 inch (3.5 mm)] diameter.
 - e. Length: To suit depth of insulation indicated.
2. Insulation Pins and Hangers - Cupped-Head, Capacitor-Discharge-Weld Pins:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - 1) [AGM Industries, Inc]
 - 2) [CL WARD & Family Inc.]
 - 3) [Gemco]
 - 4) [Midwest Fasteners, Inc]
 - 5) [Nelson Stud Welding]
 - 6) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [AGM Industries, Inc]
 - 2) [CL WARD & Family Inc.]
 - 3) [Gemco]
 - 4) [Midwest Fasteners, Inc]
 - 5) [Nelson Stud Welding]
 - 6) <Insert manufacturer's name>
 - c. Material: [Galvanized steel][Stainless steel] , fully annealed for capacitor-discharge welding.
 - d. Shank: [0.106 inch (2.6 mm)][0.135 inch (3.5 mm)] diameter.
 - e. Length: To suit depth of insulation indicated, with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
3. Insulation Hangers - Metal, Adhesively Attached, Perforated Base:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - 1) [AGM Industries, Inc]
 - 2) [Gemco]
 - 3) [Midwest Fasteners, Inc]
 - 4) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) [AGM Industries, Inc]
 - 2) [Gemco]
 - 3) [Midwest Fasteners, Inc]
 - 4) <Insert manufacturer's name>
- c. Description: Baseplate welded to projection spindle that is capable of holding insulation, of thickness indicated in schedules, securely in position indicated when self-locking washer is in place.
 - d. Baseplate Material: Perforated, galvanized carbon-steel sheet, **0.030 inch (0.76 mm)** thick by **2 inches (50 mm)** square.
 - e. Spindle: **[Copper- or zinc-coated, low-carbon steel][Aluminum][Stainless steel]** , fully annealed, **0.106-inch- (2.6-mm-)** diameter shank, length to suit depth of insulation indicated in schedules.
 - f. Adhesive: Recommended in writing by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates without damaging insulation, hangers, and substrates.
4. Insulation Hangers - Nonmetal, Adhesively Attached, Perforated Base:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - 1) [Gemco]
 - 2) [Midwest Fasteners, Inc]
 - 3) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) [Gemco]
 - 2) [Midwest Fasteners, Inc]
 - 3) <Insert manufacturer's name>
 - c. Description: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated in schedules, securely in position indicated when self-locking washer is in place.
 - d. Baseplate Material: Perforated nylon sheet, **0.030 inch (0.76 mm)** thick by **1-1/2 inches (38 mm)** in diameter.
 - e. Spindle: Nylon, **0.106-inch- (2.6-mm-)** diameter shank, length to suit depth of insulation indicated in schedules, up to **2-1/2 inches (63 mm)**.
 - f. Adhesive: Recommended in writing by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates without damaging insulation, hangers, and substrates.
 5. Insulation Hangers - Self-Sticking Base:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - 1) [AGM Industries, Inc]

- 2) **[Gemco]**
 - 3) **[Midwest Fasteners, Inc]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[AGM Industries, Inc]**
 - 2) **[Gemco]**
 - 3) **[Midwest Fasteners, Inc]**
 - 4) **<Insert manufacturer's name>**
 - c. Description: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated in schedules, securely in position indicated when self-locking washer is in place.
 - d. Baseplate Material: Galvanized carbon-steel sheet, **0.030 inch (0.76 mm)** thick by **2 inches (50 mm)** square.
 - e. Spindle: **[Copper- or zinc-coated, low-carbon steel][Aluminum][Stainless steel]** , fully annealed, **0.106-inch- (2.6-mm-)** diameter shank, length to suit depth of insulation indicated in schedules.
 - f. Adhesive-backed base with a peel-off protective cover.
6. Insulation Washers - Insulation Retaining:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - 1) **[AGM Industries, Inc]**
 - 2) **[Gemco]**
 - 3) **[Midwest Fasteners, Inc]**
 - 4) **[Nelson Stud Welding]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[AGM Industries, Inc]**
 - 2) **[Gemco]**
 - 3) **[Midwest Fasteners, Inc]**
 - 4) **[Nelson Stud Welding]**
 - 5) **<Insert manufacturer's name>**
 - c. Description: Self-locking washers formed from **0.016-inch- (0.41-mm-)** thick, **[galvanized-steel][aluminum][stainless steel]** sheet, with beveled edge sized as required to hold insulation securely in place but not less than **1-1/2 inches (38 mm)** in diameter.
 - d. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
7. Insulation Washers - Nonmetal, Insulation Retaining:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following] :

- 1) **[Gemco]**
- 2) **[Midwest Fasteners, Inc]**
- 3) **<Insert manufacturer's name>**

- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) **[Gemco]**
- 2) **[Midwest Fasteners, Inc]**
- 3) **<Insert manufacturer's name>**

- c. Description: Self-locking washers formed from **0.016-inch- (0.41-mm-)** thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than **1-1/2 inches (38 mm)** in diameter.

- C. Insulation Staples: Outward-clinching insulation staples, nominal **3/4 inch (19 mm)** wide, stainless steel or Monel.

- D. Insulation Wire:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :**
 - a. **[C & F Wire Products]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[RPR Products, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[C & F Wire Products]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[RPR Products, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Description: **[0.080-inch (2.0-mm) nickel-copper alloy][0.062-inch (1.6-mm) soft-annealed, stainless steel][0.062-inch (1.6-mm) soft-annealed, galvanized steel] .**

2.16 INSULATION CORNER ANGLES

- A. Insulation Corner Angle - PVC:

1. Thickness: **[30 mils (0.8 mm)]<Insert dimension> .**
2. Dimensions: Minimum **1 by 1 inch (25 by 25 mm)**.
3. Material: PVC in accordance with ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Insulation Corner Angle - Aluminum:

1. Thickness: **[0.040 inch (1.0 mm)]<Insert dimension>** .
2. Dimensions: Minimum **1 by 1 inch (25 by 25 mm)**.
3. Material: Aluminum in accordance with **ASTM B209 (ASTM B209M)**, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Insulation Corner Angle - Stainless Steel:

1. Thickness: **[0.024 inch (0.61 mm)]<Insert dimension>** .
2. Dimensions: Minimum **1 by 1 inch (25 by 25 mm)**.
3. Material: Stainless steel in accordance with ASTM A240/A240M, **[Type 304][or][Type 316]** .

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that duct systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSULATION INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents [, **unless otherwise approved by the Engineer-of-record**] .
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 - 2. Cover circumferential joints with **3-inch- (75-mm-)** wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced **4 inches (100 mm)** o.c.
 - 3. Overlap jacket longitudinal seams at least **1-1/2 inches (38 mm)**. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [**2 inches (50 mm)**][**4 inches (100 mm)**] o.c.
 - 4. For below ambient services, apply vapor-barrier mastic over staples.
 - 5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 - 6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least **4 inches (100 mm)** beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 INSTALLATION OF INSULATION AT PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least **2 inches (50 mm)** below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least **2 inches (50 mm)**.
 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations That Are Not Fire Rated: Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least **2 inches (50 mm)**.
1. Comply with requirements in Section 078413 "Penetration Firestopping."
- E. Insulation Installation at Floor Penetrations:
1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least **2 inches (50 mm)**.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC DUCT INSULATION

- A. Comply with manufacturer's written installation instructions and ASTM C1710.
- B. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Square and Rectangular Ducts and Plenums:
1. Provide **1/4 inch (6.4 mm)** more per side for a tight, compression fit.
 2. Cut sheet insulation with the following dimensions:
 - a. Width of duct plus **1/4 inch (6.4 mm)**, one piece.
 - b. Height of duct plus **1/4 inch (6.4 mm)**, plus thickness of insulation, two pieces.
 - c. Width of duct plus **1/4 inch (6.4 mm)**, plus two times the thickness of insulation, one piece.
 3. Insulate the bottom of the duct with the sheet from (a) above, then the sides with the two sheets from (b) above, and finally the top of the duct with the sheet from (c) above.
 4. Insulation without self-adhering backing:
 - a. Apply 100 percent coverage of manufacturer adhesive on the metal surface, then the insulation, except for the last **1/4 inch (6.4 mm)** where sheets will butt together.
 - b. Roll sheet down into position.
 - c. Press two sheets together under compression and apply adhesive at the butt joint to seal the two sheets together.
 5. Insulation with self-adhering backing:
 - a. Peel back release paper in **6- to 8-inch (150- to 203-mm)** increments and line up sheet.
 - b. Press firmly to activate adhesive.

- c. Align material and continue to line up correctly, pressing firmly while slowly removing release paper.
 - d. Allow **1/4-inch (6.4-mm)** overlap for compression at butt joints.
 - e. Apply adhesive at the butt joint to seal the two sheets together.
6. Insulate duct brackets following manufacturer's written installation instructions.

D. Circular Ducts:

1. Determine the circumference of the duct, using a strip of insulation the same thickness as to be used.
2. Cut the sheet to the required size.
3. Apply 100 percent coverage of manufacturer adhesive on the metal surface then the insulation.
4. Apply manufacturer adhesive to the cut surfaces along 100 percent of the longitudinal seam. Press together the seam at the ends and then the middle. Close the entire seam starting from the middle.

- E. Finish: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

3.6 INSTALLATION OF POLYOLEFIN DUCT INSULATION

- A. Comply with manufacturer's written installation instructions and ASTM C1710.

- B. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Square and Rectangular Ducts and Plenums:

1. Provide **1/4 inch (6.4 mm)** more per side for a tight, compression fit.
2. Cut sheet insulation with the following dimensions:
 - a. Width of duct plus **1/4 inch (6.4 mm)**, one piece.
 - b. Height of duct plus **1/4 inch (6.4 mm)**, plus thickness of insulation, two pieces.
 - c. Width of duct plus **1/4 inch (6.4 mm)**, plus two times the thickness of insulation, one piece.
3. Insulate the bottom of the duct with the sheet from (a) above, then the sides with the two sheets from (b) above, and finally the top of the duct with the sheet from (c) above.
4. Insulation without self-adhering backing:
 - a. Apply 100 percent coverage of manufacturer adhesive on the metal surface, then the insulation, except for the last **1/4 inch (6.4 mm)** where sheets will butt together.
 - b. Roll sheet down into position.
 - c. Press two sheets together under compression and apply adhesive at the butt joint to seal the two sheets together.
5. Insulation with self-adhering backing:
 - a. Peel back release paper in **6- to 8-inch (150- to 203-mm)** increments and line up sheet.
 - b. Press firmly to activate adhesive.
 - c. Align material and continue to line up correctly, pressing firmly while slowly removing release paper.
 - d. Allow **1/4-inch (6.4-mm)** overlap for compression at butt joints.
 - e. Apply adhesive at the butt joint to seal the two sheets together.

6. Insulate duct brackets following manufacturer's written installation instructions.

D. Circular Ducts:

1. Determine the circumference of the duct, using a strip of insulation the same thickness as to be used.
2. Cut the sheet to the required size.
3. Apply 100 percent coverage of manufacturer adhesive on the metal surface then the insulation.
4. Apply manufacturer adhesive to the cut surfaces along 100 percent of the longitudinal seam. Press together the seam at the ends and then the middle. Close the entire seam starting from the middle.

3.7 INSTALLATION OF GLASS-FIBER DUCT INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

- B. Comply with manufacturer's written installation instructions.

1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for **[100][50]<Insert number>** percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Weld-Pin Installation: Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions **18 inches (450 mm)** and smaller, place pins along longitudinal centerline of duct. Space **3 inches (75 mm)** maximum from insulation end joints, and **16 inches (400 mm)** o.c.
 - b. On duct sides with dimensions larger than **18 inches (450 mm)**, place pins **16 inches (400 mm)** o.c. each way, and **3 inches (75 mm)** maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing **2 inches (50 mm)** from one edge and one end of insulation segment. Secure laps to adjacent insulation section with **1/2-inch (13-mm)** outward-clinching staples, **1 inch (25 mm)** o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below **50 deg F (10 deg C)** at **18-ft. (5.5-m)** intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than **3 inches (75 mm)**.
5. Overlap unfaced blankets a minimum of **2 inches (50 mm)** on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of **18 inches (450 mm)** o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each

surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with **6-inch- (150-mm-)** wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced **6 inches (150 mm)** o.c.

C. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for **[100][50]<Insert number>** percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Weld-Pin Installation: Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions **18 inches (450 mm)** and smaller, place pins along longitudinal centerline of duct. Space **3 inches (75 mm)** maximum from insulation end joints, and **16 inches (400 mm)** o.c.
 - b. On duct sides with dimensions larger than **18 inches (450 mm)**, space pins **16 inches (400 mm)** o.c. each way, and **3 inches (75 mm)** maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing **2 inches (50 mm)** from one edge and one end of insulation segment. Secure laps to adjacent insulation section with **1/2-inch (13-mm)** outward-clinching staples, **1 inch (25 mm)** o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below **50 deg F (10 deg C)** at **18-ft. (5.5-m)** intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than **3 inches (75 mm)**.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with **6-inch- (150-mm-)** wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced **6 inches (150 mm)** o.c.

3.8 INSTALLATION OF MINERAL WOOL DUCT INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
- B. Comply with manufacturer's written installation instructions.

1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for **[100][50]<Insert number>** percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Weld-Pin Installation: Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions **18 inches (450 mm)** and smaller, place pins along longitudinal centerline of duct. Space **3 inches (75 mm)** maximum from insulation end joints, and **16 inches (400 mm)** o.c.
 - b. On duct sides with dimensions larger than **18 inches (450 mm)**, place pins **16 inches (400 mm)** o.c. each way, and **3 inches (75 mm)** maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing **2 inches (50 mm)** from one edge and one end of insulation segment. Secure laps to adjacent insulation section with **1/2-inch (13-mm)** outward-clinching staples, **1 inch (25 mm)** o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below **50 deg F (10 deg C)** at **18-ft. (5.5-m)** intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than **3 inches (75 mm)**.
 5. Overlap unfaced blankets a minimum of **2 inches (50 mm)** on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of **18 inches (450 mm)** o.c.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with **6-inch- (150-mm-)** wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced **6 inches (150 mm)** o.c.
- C. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for **[100][50]<Insert number>** percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions **18 inches (450 mm)** and smaller, place pins along longitudinal centerline of duct. Space **3 inches (75 mm)** maximum from insulation end joints, and **16 inches (400 mm)** o.c.
 - b. On duct sides with dimensions larger than **18 inches (450 mm)**, space pins **16 inches**

- (400 mm) o.c. each way, and **3 inches (75 mm)** maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
- c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing **2 inches (50 mm)** from one edge and one end of insulation segment. Secure laps to adjacent insulation section with **1/2-inch (13-mm)** outward-clinching staples, **1 inch (25 mm)** o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
- a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below **50 deg F (10 deg C)** at **18-ft. (5.5-m)** intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than **3 inches (75 mm)**.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with **6-inch- (150-mm-)** wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced **6 inches (150 mm)** o.c.

3.9 INSTALLATION OF FIELD-APPLIED CLOTHS FOR INSULATION

- A. Where woven glass-fiber jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
- 1. Draw jacket smooth and tight to surface with **2-inch (50-mm)** overlap at seams and joints.
 - 2. Embed glass cloth between two **0.062-inch- (1.6-mm-)** thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
- 1. Draw jacket smooth and tight to surface with **2-inch (50-mm)** overlap at seams and joints.
 - 2. Embed glass cloth between two **0.062-inch- (1.6-mm-)** thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.

3.10 INSTALLATION OF FIELD-APPLIED INSULATION JACKETS

- A. Insulation Jacket, Field Applied - FSK:
- 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with **1-1/2-inch (38-mm)** laps at longitudinal seams and **3-inch- (75-mm-)** wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Insulation Jacket, Field Applied - PVC:

1. Install with **1-inch (25-mm)** overlap at longitudinal seams and end joints.
2. Seal with manufacturer's recommended adhesive.
3. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Insulation Jacket, Field Applied - Metal:

1. Install with **2-inch (50-mm)** overlap at longitudinal seams and end joints.
2. Overlap longitudinal seams arranged to shed water.
3. Seal end joints with weatherproof sealant recommended by insulation manufacturer.
4. Secure jacket with stainless steel bands **12 inches (300 mm)** o.c. and at end joints.

3.11 INSTALLATION OF FIRE-RATED DUCT INSULATION SYSTEMS

- A. Comply with manufacturer's written installation instructions.
- B. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- C. Insulate duct access panels and doors to achieve same fire rating as duct.
- D. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.12 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
 1. Flat Acrylic Finish: **[Two]<Insert number>** finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless steel jackets.

3.13 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.



- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components and assemblies including connections.
- C. Perform tests and inspections [**with the assistance of a factory-authorized service representative**] .
- D. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation.
 - 2. Extent of inspection is limited to **[one]<Insert number>** location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- E. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.
- F. Prepare test and inspection reports.

3.14 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
 - 5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
 - 6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
 - 7. Indoor, concealed oven and warewash exhaust.
 - 8. Indoor, exposed oven and warewash exhaust.
 - 9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 - 11. Outdoor, concealed supply and return.
 - 12. Outdoor, exposed supply and return.
- B. Items Not Insulated:
 - 1. Fibrous-glass ducts.
 - 2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 - 3. Factory-insulated flexible ducts.
 - 4. Factory-insulated plenums and casings.
 - 5. Flexible connectors.
 - 6. Vibration-control devices.
 - 7. Factory-insulated access panels and doors.

3.15 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, Round and Flat-Oval, Supply-Air Duct Insulation: To be one of the following:
 - 1. Duct Insulation Wrap - Flexible Elastomeric: **[1 inch (25 mm)]<Insert dimension>** thick.
 - 2. Duct Insulation Wrap - Glass-Fiber Blanket: **[1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension>** thick and **[0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)]** nominal density.

3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 4. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- B. Concealed, Round and Flat-Oval, Return-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 4. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- C. Concealed, Round and Flat-Oval, Outdoor-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 4. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- D. Concealed, Round and Flat-Oval, Exhaust-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 4. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- E. Concealed, Rectangular, Supply-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- F. Concealed, Rectangular, Return-Air Duct Insulation: To be one of the following:

1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- G. Concealed, Rectangular, Outdoor-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- H. Concealed, Rectangular, Exhaust-Air Duct Insulation between Isolation Damper and Penetration of Building Exterior: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- I. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: [**Duct Insulation - Fire-Rated Blanket**][**Duct Insulation - Fire-Rated Board**] ; thickness as required to achieve fire rating indicated under Part 2 product type.
- J. Concealed, Supply-Air Plenum Insulation: To be one of the following:

1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- K. Concealed, Return-Air Plenum Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- L. Concealed, Outdoor-Air Plenum Insulation: To be one of the following:
1. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 2. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 4. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
- M. Concealed, Exhaust-Air Plenum Insulation: To be one of the following:
1. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 2. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert

dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

4. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

N. Exposed, Round and Flat-Oval, Supply-Air Duct Insulation: To be one of the following:

1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
3. Duct Insulation Wrap - Glass-Fiber, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
5. Duct Insulation Wrap - Mineral Wool, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.

O. Exposed, Round and Flat-Oval, Return-Air Duct Insulation: To be one of the following:

1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
3. Duct Insulation Wrap - Glass-Fiber, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
5. Duct Insulation Wrap - Mineral Wool, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.

P. Exposed, Round and Flat-Oval, Outdoor-Air Duct Insulation: To be one of the following:

1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
3. Duct Insulation Wrap - Glass-Fiber, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
5. Duct Insulation Wrap - Mineral Wool, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.

Q. Exposed, Round and Flat-Oval, Exhaust-Air Duct Insulation: To be one of the following:

1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.

- (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
3. Duct Insulation Wrap - Glass-Fiber, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 5. Duct Insulation Wrap - Mineral Wool, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- R. Exposed, Rectangular, Supply-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4-lb/cu. ft. (64-kg/cu. m)][6-lb/cu. ft. (96-kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- S. Exposed, Rectangular, Return-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- T. Exposed, Rectangular, Outdoor-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density>

- nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- U. Exposed, Rectangular, Exhaust-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- V. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Duct insulation, fire-rated [**blanket**][**board**] ; thickness as required to achieve fire rating indicated in Part 2 "Fire-Rated Duct Insulation Systems" Article.
- W. Exposed, Supply-Air Plenum Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- X. Exposed, Return-Air Plenum Insulation: To be one of the following:
1. Duct Insulation Wrap - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 2. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density>

- nominal density.
 5. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Duct Insulation Wrap - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- Y. Exposed, Outdoor-Air Plenum Insulation: To be one of the following:
1. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 2. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 4. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
- Z. Exposed, Exhaust-Air Plenum Insulation: To be one of the following:
1. Duct Insulation Wrap - Glass-Fiber Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 2. Duct Insulation Wrap - Glass-Fiber Board: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 4. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
- 3.16 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE
- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
- B. Concealed, Round and Flat-Oval, Supply-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 2. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
- C. Concealed, Round and Flat-Oval, Return-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.

2. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
- D. Concealed, Round and Flat-Oval, Outdoor-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 2. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
- E. Concealed, Rectangular, Supply-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 2. Duct Insulation Wrap - Glass-Fiber Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 4. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
- F. Concealed, Rectangular, Return-Air Duct Insulation: To be one of the following:
1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 2. Duct Insulation Wrap - Glass-Fiber Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 4. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
- G. Concealed, Supply-Air Plenum Insulation: To be one of the following:
1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
 2. Duct Insulation Wrap - Glass-Fiber Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 4. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

H. Concealed, Return-Air Plenum Insulation: To be one of the following:

1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
2. Duct Insulation Wrap - Glass-Fiber Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
4. Duct Insulation Wrap - Mineral Wool Board: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

I. Exposed, Round and Flat-Oval, Supply-Air Duct Insulation: To be one of the following:

1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
2. Duct Insulation Wrap - Glass-Fiber, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
3. Duct Insulation Wrap - Mineral Wool Blanket: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
4. Duct Insulation Wrap - Mineral Wool, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.

J. Exposed, Round and Flat-Oval, Return-Air Duct Insulation: To be one of the following:

1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
2. Duct Insulation Wrap - Glass-Fiber Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Duct Insulation Wrap - Mineral Wool Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
4. Duct Insulation Wrap - Mineral Wool Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

K. Exposed, Rectangular, Supply-Air Duct Insulation: To be one of the following:

1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
2. Duct Insulation Wrap - Glass-Fiber Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Duct Insulation Wrap - Mineral Wool Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density>

4. nominal density.
Duct Insulation Wrap - Mineral Wool Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

L. Exposed, Rectangular, Return-Air Duct Insulation: To be one of the following:

1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
2. Duct Insulation Wrap - Glass-Fiber Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Duct Insulation Wrap - Mineral Wool Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
4. Duct Insulation Wrap - Mineral Wool Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

M. Exposed, Supply-Air Plenum Insulation: To be one of the following:

1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
2. Duct Insulation Wrap - Glass-Fiber Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Duct Insulation Wrap - Mineral Wool Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
4. Duct Insulation Wrap - Mineral Wool Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

N. Exposed, Return-Air Plenum Insulation: To be one of the following:

1. Duct Insulation Wrap - Glass-Fiber Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> and [0.75 lb/cu. ft. (12 kg/cu. m)][1.5 lb/cu. ft. (24 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)] nominal density.
2. Duct Insulation Wrap - Glass-Fiber Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Duct Insulation Wrap - Mineral Wool Blanket: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
4. Duct Insulation Wrap - Mineral Wool Board: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

3.17 INDOOR, FIELD-APPLIED INSULATION JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Concealed from View:
1. None.
 2. PVC: **[Standard][Color-coded by system]** .
 - a. Thickness: **[20 mils (0.5 mm)][30 mils (0.8 mm)]** .
 3. Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
 4. Painted Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)]** .
 5. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth 2B finish][corrugated][stucco embossed]** .
 - a. Thickness: **[0.010 inch (0.25 mm)][0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .
- D. Ducts and Plenums, Exposed to View:
1. None.
 2. PVC: **[Standard][Color-coded by system]** .
 - a. Thickness: **[20 mils (0.5 mm)][30 mils (0.8 mm)]** .
 3. Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
 4. Painted Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)]** .
 5. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth 2B finish][corrugated][stucco embossed]** .
 - a. Thickness: **[0.010 inch (0.25 mm)][0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .

3.18 OUTDOOR, FIELD-APPLIED INSULATION JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.

- C. Ducts and Plenums, Concealed from View:
1. None.
 2. PVC: **[Standard][Color-coded by system]** .
 - a. Thickness: **[20 mils (0.5 mm)][30 mils (0.8 mm)]** .
 3. Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
 4. Painted Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)]** .
 5. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth 2B finish][corrugated][stucco embossed]** .
 - a. Thickness: **[0.010 inch (0.25 mm)][0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .
- D. Ducts and Plenums, Exposed to View, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
1. Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
 2. Painted Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)]** .
 3. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth 2B finish][corrugated][stucco embossed]** .
 - a. Thickness: **[0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .
- E. Ducts and Plenums, Exposed to View, Larger than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger than 72 Inches (1800 mm):
1. PVC: **[Standard][Color-coded by system]** .
 - a. Thickness: **[20 mils (0.5 mm)][30 mils (0.8 mm)][40 mils (1.0 mm)]** .
 2. Aluminum: **[Smooth][Stucco embossed]** , with **[1-1/4-inch- (32-mm-) deep corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs]** .
 - a. Thickness: **[0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
 3. Painted Aluminum: **[Smooth][Stucco embossed]** , with **[1-1/4-inch- (32-mm-) deep**



corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs]

a. Thickness: **[0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .

4. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth][stucco embossed]** , with **[1-1/4-inch- (32-mm-) deep corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs]** .

a. Thickness: **[0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .

END OF SECTION 23 07 13 00



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 07 16 00 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Calcium-silicate equipment insulation.
2. Cellular-glass equipment insulation.
3. Flexible elastomeric equipment insulation.
4. Glass-fiber equipment insulation.
5. Mineral wool equipment insulation.
6. Polyisocyanurate equipment insulation.
7. Polyolefin equipment insulation.
8. Polystyrene equipment insulation.
9. Insulating cements.
10. Insulation adhesives.
11. Insulation mastics and coatings.
12. Insulation sealants.
13. Field-applied insulation jackets.
14. Field-applied fabric-reinforcing mesh for insulation.
15. Field-applied cloths for insulation.
16. Vapor-retarder tapes.
17. Insulation securements.
18. Insulation corner angles.

B. Related Requirements:

1. Section 230713 "Duct Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of specified product. Include thermal conductivity, water-vapor permeance, thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail removable insulation at equipment connections.
2. Detail application of field-applied jackets.
3. Detail application at linkages of control devices.
4. Detail field application for each equipment type.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Sheet Form Insulation Materials: **12 inches (300 mm)** square.
2. Sheet Jacket Materials: **12 inches (300 mm)** square.
3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating percentage of postconsumer and preconsumer recycled content and cost.
2. Environmental Product Declaration (EPD): For each product.
3. Health Product Declaration (HPD): For each product.
4. Environmental Product Declaration (EPD): For each product.
5. Health Product Declaration (HPD): For each product.
6. Environmental Product Declaration (EPD): For each product.
7. Environmental Product Declaration (EPD): For each product.
8. Environmental Product Declaration (EPD): For each product.
9. Third-Party Certifications: For each product.
10. Third-Party-Certified Life-Cycle Assessment: For each product.
11. Product Data: For sealants, indicating VOC content.
12. Laboratory Test Reports: For sealers, indicating compliance with requirements for low-emitting materials.

1.3 INFORMATIONAL SUBMITTALS

- A. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- B. Field Quality Control Reports: For specified tests and inspections.
- C. Qualification Statements: For Installer.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program [, **certified by the Department of Labor, Bureau of Apprenticeship and Training**] .

1.5 MOCKUPS

- A. Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
 1. Equipment Mockups:
 - a. One chilled-water pump and one heating-hot-water pump.
 - b. One tank or vessel.
 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
 3. Notify Architect [**seven**]~~<Insert number>~~ days in advance of dates and times when mockups will be constructed.
 4. Obtain Architect's approval of mockups before starting insulation application.
 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.

6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation system materials are to be delivered to Project site in unopened containers. The packaging is to include the name of the manufacturer, fabricator, type, description, and size [, **as well as ASTM standard designation and maximum use temperature**] .

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with equipment Installer for equipment insulation application. Before preparing equipment Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes, and for space required for maintenance.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 2. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 3. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 EQUIPMENT INSULATION MATERIALS, GENERAL

- A. Comply with requirements in "Breeching Insulation Schedule," "Indoor HVAC Equipment Insulation Schedule," and "Outdoor, Aboveground Equipment Insulation Schedule" articles for where insulating materials are applied.
- B. Products are not to contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel are to have a leachable chloride content of less than

50 ppm when tested in accordance with ASTM C871.

- D. Insulation materials for use on austenitic stainless steel are to be qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials are not to use CFC or HCFC blowing agents in the manufacturing process.

2.3 CALCIUM-SILICATE EQUIPMENT INSULATION

A. Equipment Insulation - Calcium Silicate:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[TPS Industrial; a trademark of Chase Manufacturing, Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[TPS Industrial; a trademark of Chase Manufacturing, Inc.]**
 - c. **<Insert manufacturer's name>**
3. Description: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement.
4. Standard: ASTM C533, Type I or Type II.
5. Prefabricated Fitting Covers: ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.4 CELLULAR-GLASS EQUIPMENT INSULATION

A. Equipment Insulation - Cellular Glass:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Owens Corning]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Owens Corning]**
 - b. **<Insert manufacturer's name>**

3. Description: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells.
4. Standard: ASTM C552.
5. Block Insulation: Type I.
6. Special-Shaped Insulation: Type III.
7. Board Insulation: Type IV.
8. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
9. Equipment insulation without facing.
10. Equipment Insulation with Factory-Applied Facing:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 - b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 - c. FSK Facing: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type III.
 - d. FSP Facing: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type III.
 - e. Vinyl Facing: White vinyl with a permeance of **1.3 perms (0.86 metric perm)** when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.5 FLEXIBLE ELASTOMERIC EQUIPMENT INSULATION

A. Equipment Insulation - Flexible Elastomeric:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**
 - c. **[K-Flex USA]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**
 - c. **[K-Flex USA]**
 - d. **<Insert manufacturer's name>**
3. Description: Closed-cell or expanded-rubber flexible elastomeric equipment insulation.
4. Standard: ASTM C534/C534M, Type II for sheet materials.
5. Suitable for use temperature between **minus 70 deg F (minus 57 deg C)** and **plus 220 deg F (plus 104 deg C)**.

2.6 GLASS-FIBER EQUIPMENT INSULATION

A. Equipment Insulation - Glass-Fiber Blanket:



1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
3. Description: Glass fiber blanket equipment insulation consisting of glass fibers bonded with a thermosetting resin.
4. Suitable for maximum use temperature up to **450 deg F (232 deg C)** in accordance with ASTM C411.
5. Unfaced, Type I.
6. Factory-Applied Insulation Facing:
 - a. FSK: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type III.
 - b. Vinyl: White vinyl with a permeance of **1.3 perms (0.86 metric perm)** when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

B. Equipment Insulation - High-Temperature, Glass-Fiber Blanket:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CertainTeed; SAINT-GOBAIN]**

- b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
 3. Description: High-temperature glass-fiber equipment blanket insulation consisting of glass fibers bonded with a thermosetting resin.
 4. Standard: ASTM C553, Type V.
 5. Unfaced.
 6. Suitable for maximum use temperature up to **1000 deg F (650 deg C)**.
- C. Equipment Insulation - Glass-Fiber Board:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
 3. Description: Glass-fiber board equipment insulation consisting of glass fibers bonded with a thermosetting resin.
 4. Standard: ASTM C612, Type IA or Type IB.
 5. Suitable for maximum use temperature between **35 deg F (1.7 deg C)** and **250 deg F (121 deg C)** for jacketed and between **35 deg F (1.7 deg C)** and **450 deg F (232 deg C)** for unfaced in accordance with ASTM C411.
 6. Unfaced.
 7. Factory-Applied Insulation Facing:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type III.
 - b. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type III.
- D. Equipment Insulation - High-Temperature, Glass-Fiber Board:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following] :

- a. [CertainTeed; SAINT-GOBAIN]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [Knauf Insulation]
 - d. [Manson Insulation Inc.]
 - e. [Owens Corning]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CertainTeed; SAINT-GOBAIN]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [Knauf Insulation]
 - d. [Manson Insulation Inc.]
 - e. [Owens Corning]
 - f. <Insert manufacturer's name>
3. Description: High-temperature, glass-fiber board insulation consisting of glass fibers bonded with a thermosetting resin.
4. Standard: ASTM C612, Type III, unfaced.
5. Suitable for maximum use temperature up to **1000 deg F (650 deg C)** in accordance with ASTM C411.

E. Equipment Insulation - Glass-Fiber, Pipe and Tank:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [CertainTeed; SAINT-GOBAIN]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [Knauf Insulation]
 - d. [Manson Insulation Inc.]
 - e. [Owens Corning]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CertainTeed; SAINT-GOBAIN]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [Knauf Insulation]
 - d. [Manson Insulation Inc.]
 - e. [Owens Corning]
 - f. <Insert manufacturer's name>
3. Description: Glass-fiber, pipe and tank insulation consisting of glass fibers bonded with a thermosetting resin.
4. Standard: ASTM C1393.
5. Suitable for use temperature between **35 deg F (1.7 deg C)** and **850 deg F (454 deg C)**, in

- accordance with ASTM C411.
- 6. Semirigid board material.
- 7. Factory-Applied Insulation Facing:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type III.
 - b. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type III.

2.7 MINERAL WOOL EQUIPMENT INSULATION

A. Equipment Insulation - Mineral Wool Blanket:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[Owens Corning]**
 - c. **[ROCKWOOL]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[Owens Corning]**
 - c. **[ROCKWOOL]**
 - d. **<Insert manufacturer's name>**
- 3. Description: Mineral wool equipment insulation blanket consisting of basalt volcanic rock-derived fibers bonded with a thermosetting resin.
- 4. Standard: ASTM C553.
- 5. Unfaced.
- 6. Suitable for maximum use temperature up to **1200 deg F (650 deg C)** in accordance with ASTM C447.

B. Equipment Insulation - Mineral Wool Board:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[Owens Corning]**
 - c. **[ROCKWOOL]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Johns Manville; a Berkshire Hathaway company]
 - b. [Owens Corning]
 - c. [ROCKWOOL]
 - d. <Insert manufacturer's name>
3. Description: Mineral wool board equipment insulation consisting of basalt volcanic rock-derived fibers bonded with a thermosetting resin.
4. Standard: ASTM C612, Type III, unfaced.
5. Suitable for maximum use temperature up to **1100 deg F (600 deg C)** in accordance with ASTM C411.

C. Equipment Insulation - Mineral Wool, Pipe and Tank:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [Owens Corning]
 - c. [ROCKWOOL]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [Owens Corning]
 - c. [ROCKWOOL]
 - d. <Insert manufacturer's name>
3. Description: Mineral wool, pipe and tank insulation consisting of fibers bonded with a thermosetting resin.
4. Standard: ASTM C1393.
5. Suitable for maximum use temperature up to **1000 deg F (538 deg C)**, in accordance with ASTM C411.
6. Semirigid board material.
7. Factory-Applied Insulation Facings:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type III.
 - b. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type III.

2.8 POLYISOCYANURATE EQUIPMENT INSULATION

A. Equipment Insulation - Polyisocyanurate:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. [Duna USA Inc.]
 - b. [Dyplast Products]
 - c. [Johns Manville; a Berkshire Hathaway company]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Duna USA Inc.]
 - b. [Dyplast Products]
 - c. [Johns Manville; a Berkshire Hathaway company]
 - d. <Insert manufacturer's name>
3. Description: Prefabricated, rigid cellular polyisocyanurate material intended for use as thermal insulation.
4. Standard: ASTM C591.
5. Type I or Type IV, except thermal conductivity (k-value) does not exceed **0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C)** after 180 days of aging.
6. Flame-spread index is to be 25 or less and smoke-developed index is to be 50 or less for thicknesses of up to **1.5 inches (38 mm)** as tested in accordance with ASTM E84.
7. Fabricated shapes in accordance with ASTM C450 and ASTM C585.

2.9 POLYOLEFIN EQUIPMENT INSULATION

A. Equipment Insulation - Polyolefin:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. [Armacell LLC]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Armacell LLC]
 - b. <Insert manufacturer's name>
3. Description: Polyethylene type of polyolefin thermal plastic equipment insulation.
4. Standard: ASTM C1427, Type I, Grade I for tubular materials and Type II, Grade I for sheet materials.

2.10 POLYSTYRENE EQUIPMENT INSULATION

A. Equipment Insulation - Polystyrene:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. [Dow Chemical Co., sold through Polyguard Products, Inc.]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Dow Chemical Co., sold through Polyguard Products, Inc.]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. <Insert manufacturer's name>
3. Description: Rigid, extruded cellular polystyrene intended for use as thermal insulation.
4. Standards: ASTM C578, Type IV or VIII.
5. Fabricate shapes in accordance with ASTM C450 and ASTM C585.

2.11 INSULATING CEMENTS

A. Insulating Cement for Glass Fiber and Mineral Wool:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Ramco Insulation, Inc.]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Ramco Insulation, Inc.]
 - b. <Insert manufacturer's name>
3. Standard: ASTM C195.

B. Insulating Cement for Expanded or Exfoliated Vermiculite:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Ramco Insulation, Inc.]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Ramco Insulation, Inc.]
 - b. <Insert manufacturer's name>

3. Standard: ASTM C196.

C. Hydraulic-Setting Insulating and Finishing Cement for Glass Fiber and Mineral Wool:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Ramco Insulation, Inc.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ramco Insulation, Inc.]**
 - b. **<Insert manufacturer's name>**
3. Standard: ASTM C449.

2.12 INSULATION ADHESIVES

A. Materials are to be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Insulation Adhesive for Lagging Cloth:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Vimasco Corporation]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Vimasco Corporation]**
 - d. **<Insert manufacturer's name>**
3. Standard: MIL-A-3316C, Class I, Grade A.
4. Adhesives to be compatible with insulation materials, jackets, and substrates.
5. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
6. Service Temperature Range: **[Plus 20 to 180 deg F (Minus 6 to plus 82 deg C)][0 to plus 180 deg F (Minus 18 to plus 82 deg C)]** .
7. Color: White.
8. Verify adhesive is as recommended by insulation manufacturer and has a VOC content of

[50]<Insert number> g/L or less.

C. Insulation Adhesive for Calcium Silicate:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **[Vimasco Corporation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **[Vimasco Corporation]**
 - e. **<Insert manufacturer's name>**
3. Description: Fibrous, sodium-silicate-based adhesive with a service temperature range of **50 to 800 deg F (10 to 427 deg C)**.
4. Adhesive: As recommended by adhesive manufacturer and with a VOC content of 80 g/L or less.

D. Insulation Adhesive for Cellular Glass:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
3. Description: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of **minus 100 to plus 200 deg F (minus 73 to plus 93 deg C)**.
4. Adhesive: As recommended by cellular-glass manufacturer and with a VOC content of 80 g/L or less.

E. Insulation Adhesive for Polyisocyanurate:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
 3. Description: Solvent-based resin adhesive, with a service temperature range of **minus 75 to plus 300 deg F (minus 59 to plus 149 deg C)**.
 4. Adhesive: As recommended by phenolic and polyisocyanurate manufacturer and with a VOC content of 50 g/L or less.
- F. Insulation Adhesive, Solvent Based for Flexible Elastomeric and Polyolefin:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**
 - c. **[K-Flex USA]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**
 - c. **[K-Flex USA]**
 - d. **<Insert manufacturer's name>**
 3. Adhesive: As recommended by flexible elastomeric and polyolefin manufacturer and with a VOC content of **[80]<Insert value> g/L** or less.
 4. Description: Solvent-based adhesive for flexible elastomeric and polyolefin insulation.
 5. Flame-spread index is 25 or less and smoke-developed index is 50 or less as tested in accordance with ASTM E84.
 6. Wet Flash Point: Below **0 deg F (minus 18 deg C)**.
 7. Service Temperature Range: **40 to 200 deg F (4 to plus 93 deg C)**.
 8. Color: **[Black]<Insert color>** .
- G. Insulation Adhesive for Glass Fiber and Mineral Wool:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [Childers Brand; H. B. Fuller Construction Products]
- b. [Foster Brand; H. B. Fuller]
- c. [Mon-Eco Industries, Inc.]
- d. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Childers Brand; H. B. Fuller Construction Products]
- b. [Foster Brand; H. B. Fuller]
- c. [Mon-Eco Industries, Inc.]
- d. <Insert manufacturer's name>

3. Standard: MIL-A-3316C, Class 2, Grade A.
4. Verify fiberglass adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).
5. Adhesive: As recommended by mineral-fiber manufacturer and with a VOC content of 80 g/L or less.

H. Insulation Adhesive for Polystyrene:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [Childers Brand; H. B. Fuller Construction Products]
- b. [Foster Brand; H. B. Fuller]
- c. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Childers Brand; H. B. Fuller Construction Products]
- b. [Foster Brand; H. B. Fuller]
- c. <Insert manufacturer's name>

3. Description: Solvent- or water-based, synthetic resin adhesive with a service temperature range of **minus 20 to plus 140 deg F (29 to plus 60 deg C)**.
4. Adhesive: As recommended by polystyrene manufacturer and with a VOC content of 50 g/L or less.

I. Insulation Adhesive for ASJ, FSK, and PVDC Facings/Jackets:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [Childers Brand; H. B. Fuller Construction Products]

- b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
 - 3. Description: Adhesive for bonding ASJ, FSK, and PVDC jacket lap seams and joints.
 - 4. Standard: MIL-A-3316C, Class 2, Grade A.
 - 5. Verify adhesives have a VOC content of 80 g/L or less.
- J. Insulation Adhesive for PVC Jackets:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[P.I.C. Plastics, Inc.]**
 - c. **[Proto Corporation]**
 - d. **[Sekisui Voltek, LLC]**
 - e. **[Speedline Corporation]**
 - f. **[The Dow Chemical Company]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[P.I.C. Plastics, Inc.]**
 - c. **[Proto Corporation]**
 - d. **[Sekisui Voltek, LLC]**
 - e. **[Speedline Corporation]**
 - f. **[The Dow Chemical Company]**
 - g. **<Insert manufacturer's name>**
 - 3. Adhesive: As recommended by PVC jacket manufacturer and with a VOC content of 50 g/L or less.
 - 4. Description: PVC jacket adhesive to be compatible with and as recommended in PVC jacket manufacturer's literature.

2.13 INSULATION MASTICS AND COATINGS

- A. Materials are to be compatible with insulation materials, jackets, and substrates.
- 1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.
 - 2. VOC Content: 300 g/L or less.



3. Low-Emitting Materials: Verify mastic coatings comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
4. VOC Content: 300 g/L or less.
5. Low-Emitting Materials: Verify mastic coatings comply with requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
6. VOC Emissions: Verify mastic coatings contain no more than half of the chronic REL of VOCs when tested in accordance with the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.
7. Verify mastics comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
8. Verify mastics comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
9. Verify mastics comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.

B. Insulation Vapor-Retarder Mastic - Water Based, Indoor Use:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Knauf Insulation]**
 - d. **[Mon-Eco Industries, Inc.]**
 - e. **[Vimasco Corporation]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Knauf Insulation]**
 - d. **[Mon-Eco Industries, Inc.]**
 - e. **[Vimasco Corporation]**
 - f. **<Insert manufacturer's name>**
3. Description: Insulation vapor-retarder mastic, water based, suitable for indoor use on below-ambient services.
4. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.

5. Service Temperature Range: [0 to plus 180 deg F (Minus 18 to plus 82 deg C)][Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C)] .
 6. Standard: MIL-PRF-19565C, Type II, for permeance requirements [, with supplier listing on **DOD QPD - Qualified Products Database**] .
 7. Color: [White]<Insert color> .
- C. Insulation Vapor-Retarder Mastic - Solvent Based, Indoor Use:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. <Insert manufacturer's name>
 3. Description: Insulation vapor-retarder mastic, solvent based, suitable for indoor use on below-ambient services.
 4. Water-Vapor Permeance: ASTM E96/E96M or ASTM F1249.
 5. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 6. Color: [White]<Insert color> .
- D. Insulation Vapor-Retarder Mastic - Solvent Based, Outdoor Use:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. <Insert manufacturer's name>
 3. Description: Insulation vapor-retarder mastic, solvent based, suitable for outdoor use on below-ambient services.

4. Water-Vapor Permeance: ASTM E96/E96M or ASTM F1249.
5. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
6. Color: [White]<Insert color> .

E. Insulation Breather Mastic - Water Based, Indoor/Outdoor:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Knauf Insulation]
 - d. [Mon-Eco Industries, Inc.]
 - e. [Vimasco Corporation]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Knauf Insulation]
 - d. [Mon-Eco Industries, Inc.]
 - e. [Vimasco Corporation]
 - f. <Insert manufacturer's name>
3. Description: Insulation breather mastic, water based, suitable for indoor and outdoor use on above-ambient surfaces.
4. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm (0.66 metric perms) at manufacturer's recommended dry film thickness.
5. Service Temperature Range: [0 to plus 180 deg F (Minus 18 to plus 82 deg C)][Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C)] .
6. Color: [White]<Insert color> .

2.14 INSULATION SEALANTS

A. Insulation Joint Sealant:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. [Owens Corning]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. [Owens Corning]
 - e. <Insert manufacturer's name>
3. Permanently flexible, elastomeric sealant.
 4. Service Temperature Range: **[Minus 58 to plus 176 deg F (Minus 50 to plus 80 deg C)][Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C)]** .
 5. Color: White or gray.
 6. Verify sealant has a VOC content of 420 g/L or less.

B. Flashing Sealant for FSK and Metal Jackets:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. <Insert manufacturer's name>
3. Sealant to be compatible with insulation materials, jackets, and substrates.
4. Fire- and water-resistant, flexible, elastomeric sealant.
5. Service Temperature Range: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)**.
6. Color: Aluminum.
7. Verify sealant has a VOC content of 420 g/L or less.

C. Flashing Sealant for ASJ, PVDC, and PVC Jackets:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
3. Sealant to be compatible with insulation materials, jackets, and substrates.
 4. Fire- and water-resistant, flexible, elastomeric sealant.
 5. Service Temperature Range: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).**
 6. Color: White.
 7. Verify sealant has a VOC content of 420 g/L or less.

2.15 FIELD-APPLIED INSULATION JACKETS

- A. Field-applied jackets are to comply with ASTM C1136, Type I, unless otherwise indicated.
- B. Insulation Jacket, Field Applied - FSK: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. Equipment Insulation Jacket, Field Applied - PVC:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[P.I.C. Plastics, Inc.]**
 - c. **[Proto Corporation]**
 - d. **[Speedline Corporation]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[P.I.C. Plastics, Inc.]**
 - c. **[Proto Corporation]**
 - d. **[Speedline Corporation]**
 - e. **<Insert manufacturer's name>**
 3. Description: High-impact-resistant, UV-resistant PVC complying with ASTM C1784, Class 16354-C.
 4. Thickness: As indicated in "Indoor, Field-Applied Insulation Jacket Schedule" and "Outdoor, Field-Applied Insulation Jacket Schedule" articles under Part 3.
 5. Jacket: Roll stock ready for shop or field cutting and forming.
 6. Adhesive: As recommended by jacket material manufacturer.
 7. Color: **[White][Color-code jackets based on system. Color as selected by Architect]** .
 8. Factory-fabricated tank heads and tank side panels.
- D. Insulation Jacket, Field Applied - Metal:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following] :

- a. [Johns Manville; a Berkshire Hathaway company]
 - b. [RPR Products, Inc.]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [RPR Products, Inc.]
 - c. <Insert manufacturer's name>
3. Jacket Material - Aluminum:
 - a. Description: [Sheet and roll stock ready for shop or field sizing][Factory cut and rolled to size] .
 - b. Standard: **ASTM B209 (ASTM B209M)**, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - c. Finish and Thickness: As indicated in "Indoor, Field-Applied Insulation Jacket Schedule" and "Outdoor, Field-Applied Insulation Jacket Schedule" articles under Part 3.
 - d. Moisture Barrier for Indoor Applications: [1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick polysurlyn] .
 - e. Moisture Barrier for Outdoor Applications: [3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick polysurlyn] .
 - f. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
4. Jacket Material - Stainless Steel:
 - a. Description: [Sheet and roll stock ready for shop or field sizing][Factory cut and rolled to size] .
 - b. Standard: ASTM A240/A240M.
 - c. Material Type, Finish, and Thickness: As indicated in "Indoor, Field-Applied Insulation Jacket Schedule" and "Outdoor, Field-Applied Insulation Jacket Schedule" articles under Part 3.
 - d. Moisture Barrier for Indoor Applications: [1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick polysurlyn] .
 - e. Moisture Barrier for Outdoor Applications: [3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick polysurlyn] .
 - f. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.

- 5) End caps.
- 6) Beveled collars.
- 7) Valve covers.
- 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Insulation Jacket, Field Applied - Outdoor, Self Adhesive (Asphaltic):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[MFM Building Products Corp.]**
 - b. **[Polyguard Products, Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[MFM Building Products Corp.]**
 - b. **[Polyguard Products, Inc.]**
 - c. **<Insert manufacturer's name>**
3. Description: Self-adhesive outdoor asphaltic jacket of rubberized bituminous resin on a cross-laminated polyethylene film covered with **[white][stucco-embossed]** aluminum foil.
4. Vapor Barrier/Waterproofing Membrane: **60 mils (1.5 mm)** thick.

F. Insulation Jacket, Field Applied - Indoor/Outdoor, Self Adhesive (Non-Asphaltic):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[3M]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[3M]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **<Insert manufacturer's name>**
3. Description: Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors.
4. Specialized jacket consisting of five layers of laminated aluminum and polyester film.
5. Adhesive Lap: Self-adhesive, low-temperature acrylic, pressure-sensitive adhesive lap.
6. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
7. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.

8. Aluminum Finish: **[Embossed][Smooth]** .
9. Outer Aluminum Surface: Coated with UV-resistant coating for protection from environmental contaminants.

G. Insulation Jacket, Field Applied - Indoor, PVDC:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
3. Description: PVDC jacket for indoor applications with white PVDC biaxially oriented barrier film.
4. Vapor Barrier/Waterproofing Membrane: **4 mils (0.10 mm)** thick.
5. Permeance: **0.02 perm (0.013 metric perm)** when tested in accordance with ASTM E96/E96M.
6. Flame-Spread/Smoke-Developed Index: Flame-spread index of 10 and a smoke-developed index of 20 when tested in accordance with ASTM E84.

H. Insulation Jacket, Field Applied - Outdoor, PVDC:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
3. Description: PVDC jacket for outdoor applications with white PVDC biaxially oriented barrier film.
4. Vapor Barrier/Waterproofing Membrane: **6 mils (0.15 mm)** thick.
5. Permeance: **0.01 perm (0.007 metric perm)** when tested in accordance with ASTM E96/E96M.
6. Flame-Spread/Smoke-Developed Index: Flame-spread index of 25 and a smoke-developed index of 50 when tested in accordance with ASTM E84.

I. Insulation Jacket, Field Applied - PVDC-SSL:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
3. Description: PVDC jacket with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
4. Thickness: **6 mils (0.15 mm)**.
5. Permeance: **0.01 perm (0.007 metric perm)** when tested in accordance with ASTM E96/E96M.
6. Flame-Spread/Smoke-Developed Index: Flame-spread index of 25 and a smoke-developed index of 50 when tested in accordance with ASTM E84.

2.16 FIELD-APPLIED FABRIC-REINFORCING MESH FOR INSULATION

A. Woven Glass-Fiber Mesh for Equipment Insulation, Field Applied:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
3. Description: Woven glass-fiber mesh for covering equipment insulation.
4. Weight: Approximately **4 oz./sq. yd. (114 g/sq. m)**.
5. Thread Count: **5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm)**.

B. Woven Polyester Mesh for Equipment Insulation, Field Applied:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Vimasco Corporation]**
 - d. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Vimasco Corporation]**
 - d. **<Insert manufacturer's name>**
3. Description: Woven polyester mesh for covering pipe and pipe fittings insulation.
4. Weight: Approximately **1 oz./sq. yd. (34 g/sq. m)**.
5. Thread Count: **10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm)**.
6. Weave Type: Leno.

2.17 FIELD-APPLIED CLOTHS FOR INSULATION

A. Woven Glass-Fiber Cloth, Field Applied, for Insulation:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Alpha Associates, Inc.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alpha Associates, Inc.]**
 - b. **<Insert manufacturer's name>**
3. Description: Woven glass-fiber cloth.
4. Standard: MIL-C-20079H, Type I, plain weave.
5. Weave: Plain.
6. Weight: Minimum of **8 oz./sq. yd. (271 g/sq. m)**, presized.

2.18 VAPOR-RETARDER TAPES

A. Vapor-Retarder Tape for ASJ:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Avery Dennison Corporation, Specialty Tapes Division]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **[Knauf Insulation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[3M Industrial Adhesives and Tapes Division]**
- b. **[Avery Dennison Corporation, Specialty Tapes Division]**
- c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
- d. **[Knauf Insulation]**
- e. **<Insert manufacturer's name>**

3. Description: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive.
4. Standard: ASTM C1136.
5. Width: **[3 inches (75 mm)]<Insert value>** .
6. Thickness: **[11.5 mils (0.29 mm)]<Insert value>** .
7. Adhesion: **[90 ounces force/inch (1.0 N/mm)]<Insert value>** in width.
8. Elongation: **[2]<Insert number>** percent.
9. Tensile Strength: **[40 lbf/inch (7.2 N/mm)]<Insert value>** in width.
10. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. Vapor-Retarder Tape for FSK:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Avery Dennison Corporation, Specialty Tapes Division]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **[Knauf Insulation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Avery Dennison Corporation, Specialty Tapes Division]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **[Knauf Insulation]**
 - e. **<Insert manufacturer's name>**

3. Description: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive.
4. Standard: ASTM C1136.
5. Width: **[3 inches (75 mm)]<Insert value>** .
6. Thickness: **[6.5 mils (0.16 mm)]<Insert value>** .
7. Adhesion: **[90 ounces force/inch (1.0 N/mm)]<Insert value>** in width.
8. Elongation: **[2]<Insert number>** percent.
9. Tensile Strength: **[40 lbf/inch (7.2 N/mm)]<Insert value>** in width.
10. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Vapor-Retarder Tape for PVC:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following] :

- a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - c. **<Insert manufacturer's name>**
3. Description: White, vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive.
4. Suitable for indoor and outdoor applications.
5. Width: **[2 inches (50 mm)]<Insert value>** .
6. Thickness: **[6 mils (0.15 mm)]<Insert value>** .
7. Adhesion: **[64 ounces force/inch (0.7 N/mm)]<Insert value>** in width.
8. Elongation: **[500]<Insert number>** percent.
9. Tensile Strength: **[18 lbf/inch (3.3 N/mm)]<Insert value>** in width.

D. Vapor-Retarder Tape - Aluminum Foil:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Avery Dennison Corporation, Specialty Tapes Division]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **[Knauf Insulation]**
 - e. **[Sekisui Voltek, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Avery Dennison Corporation, Specialty Tapes Division]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **[Knauf Insulation]**
 - e. **[Sekisui Voltek, LLC]**
 - f. **<Insert manufacturer's name>**
3. Description: Aluminum-foil vapor-retarder tape with acrylic adhesive.
4. Width: **[2 inches (50 mm)]<Insert value>** .
5. Thickness: **[3.7 mils (0.093 mm)]<Insert value>** .
6. Adhesion: **[100 ounces force/inch (1.1 N/mm)]<Insert value>** in width.
7. Elongation: **[5]<Insert number>** percent.
8. Tensile Strength: **[34 lbf/inch (6.2 N/mm)]<Insert value>** in width.

E. Vapor-Retarder Tape - PVDC, for Indoor Applications:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. <Insert manufacturer's name>
3. Description: White vapor-retarder PVDC tape with acrylic adhesive, for indoor applications.
4. Width: [3 inches (75 mm)]<Insert value> .
5. Film Thickness: [6 mils (0.15 mm)]<Insert value> .
6. Adhesive Thickness: [1.5 mils (0.04 mm)]<Insert value> .
7. Elongation at Break: [145]<Insert number> percent.
8. Tensile Strength: [55 psi (379 kPa)]<Insert value> in width.

F. Vapor-Retarder Tape - PVDC, for Outdoor Applications:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. <Insert manufacturer's name>
3. Description: White vapor-retarder PVDC tape with acrylic adhesive, for outdoor applications.
4. Width: [3 inches (75 mm)]<Insert value> .
5. Film Thickness: [6 mils (0.15 mm)]<Insert value> .
6. Adhesive Thickness: [1.5 mils (0.04 mm)]<Insert value> .
7. Elongation at Break: [145]<Insert number> percent.
8. Tensile Strength: [55 psi (379 kPa)]<Insert value> in width.

2.19 INSULATION SECUREMENTS

A. Insulation Bands:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [Johns Manville; a Berkshire Hathaway company]
 - b. [RPR Products, Inc.]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [RPR Products, Inc.]
 - c. <Insert manufacturer's name>
 3. Insulation Bands - Stainless Steel: ASTM A240/A240M, [Type 304][or][Type 316] ; 0.015 inch (0.38 mm) thick, [1/2 inch (13 mm)][3/4 inch (19 mm)] wide with [wing seal][or][closed seal] .
 4. Insulation Bands - Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, [1/2 inch (13 mm)][3/4 inch (19 mm)] wide with [wing seal][or][closed seal] .
 5. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.
- B. Insulation Pins and Hangers:
 1. Insulation Pins and Hangers - Capacitor-Discharge-Weld Pins:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - 1) [AGM Industries, Inc]
 - 2) [Gemco]
 - 3) [Midwest Fasteners, Inc]
 - 4) [Nelson Stud Welding]
 - 5) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [AGM Industries, Inc]
 - 2) [Gemco]
 - 3) [Midwest Fasteners, Inc]
 - 4) [Nelson Stud Welding]
 - 5) <Insert manufacturer's name>
 - c. Material: [Mild steel with copper coating][Stainless steel][Aluminum] , fully annealed for capacitor-discharge welding.
 - d. Shank: [0.106 inch (2.6 mm)][0.135 inch (3.5 mm)] diameter.
 - e. Length: To suit depth of insulation indicated in schedules.
 2. Insulation Pins and Hangers - Cupped-Head, Capacitor-Discharge-Weld Pins:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

- 1) [AGM Industries, Inc]
 - 2) [CL WARD & Family Inc.]
 - 3) [Gemco]
 - 4) [Midwest Fasteners, Inc]
 - 5) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [AGM Industries, Inc]
 - 2) [CL WARD & Family Inc.]
 - 3) [Gemco]
 - 4) [Midwest Fasteners, Inc]
 - 5) <Insert manufacturer's name>
 - c. Material: [Galvanized-steel][Stainless steel] pin, fully annealed for capacitor-discharge welding.
 - d. Shank: [0.106 inch (2.6 mm)][0.135 inch (3.5 mm)] diameter.
 - e. Length: To suit depth of insulation indicated in schedules, with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
3. Insulation Pins and Hangers - Metal, Adhesively Attached, Perforated Base:
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - 1) [AGM Industries, Inc]
 - 2) [CL WARD & Family Inc.]
 - 3) [Gemco]
 - 4) [Midwest Fasteners, Inc]
 - 5) [Nelson Stud Welding]
 - 6) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [AGM Industries, Inc]
 - 2) [CL WARD & Family Inc.]
 - 3) [Gemco]
 - 4) [Midwest Fasteners, Inc]
 - 5) [Nelson Stud Welding]
 - 6) <Insert manufacturer's name>
 - c. Description: Baseplate welded to projection spindle that is capable of holding insulation, of thickness indicated in schedules, securely in position indicated when self-locking washer is in place.
 - d. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - e. Spindle: [Copper- or zinc-coated, low-carbon steel][Aluminum][Stainless steel] , fully annealed, 0.106-inch- (2.6-mm-) diameter shank; length to suit depth of insulation indicated in schedules.

- f. Adhesive: Recommended in writing by hanger manufacturer. Use product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
- 4. Insulation Hangers - Nonmetal, Adhesively Attached, Perforated Base:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - 1) **[Gemco]**
 - 2) **[Midwest Fasteners, Inc]**
 - 3) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Gemco]**
 - 2) **[Midwest Fasteners, Inc]**
 - 3) **<Insert manufacturer's name>**
 - c. Description: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated in schedules, securely in position indicated when self-locking washer is in place.
 - d. Baseplate Material: Perforated, nylon sheet, **0.030 inch (0.76 mm)** thick by **1-1/2 inches (38 mm)** in diameter.
 - e. Spindle: Nylon, **0.106-inch- (2.6-mm-)** diameter shank; length to suit depth of insulation indicated in schedules, up to **2-1/2 inches (63 mm)**.
 - f. Adhesive: Recommended in writing by hanger manufacturer. Use product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
- 5. Insulation Hangers - Self-Sticking Base:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - 1) **[AGM Industries, Inc]**
 - 2) **[Gemco]**
 - 3) **[Midwest Fasteners, Inc]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[AGM Industries, Inc]**
 - 2) **[Gemco]**
 - 3) **[Midwest Fasteners, Inc]**
 - 4) **<Insert manufacturer's name>**
 - c. Description: Baseplate welded to projecting spindle that is capable of holding insulation, of

- thickness indicated in schedules, securely in position indicated when self-locking washer is in place.
- d. Baseplate Material: Galvanized carbon-steel sheet, **0.030 inch (0.76 mm)** thick by **2 inches (50 mm)** square.
 - e. Spindle: **[Copper- or zinc-coated, low-carbon steel][Aluminum][Stainless steel]** , fully annealed; **0.106-inch- (2.6-mm-)** diameter shank; length to suit depth of insulation indicated in schedules.
 - f. Adhesive-backed base with a peel-off protective cover.
6. Insulation Washers - Insulation Retaining:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - 1) **[AGM Industries, Inc]**
 - 2) **[Gemco]**
 - 3) **[Midwest Fasteners, Inc]**
 - 4) **[Nelson Stud Welding]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[AGM Industries, Inc]**
 - 2) **[Gemco]**
 - 3) **[Midwest Fasteners, Inc]**
 - 4) **[Nelson Stud Welding]**
 - 5) **<Insert manufacturer's name>**
 - c. Description: Self-locking washers formed from **0.016-inch- (0.41-mm-)** thick, **[galvanized-steel][aluminum][stainless steel]** sheet, with beveled edge sized as required to hold insulation securely in place but not less than **1-1/2 inches (38 mm)** in diameter.
 - d. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
7. Insulation Washers - Nonmetal, Insulation Retaining:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - 1) **[Gemco]**
 - 2) **[Midwest Fasteners, Inc]**
 - 3) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Gemco]**
 - 2) **[Midwest Fasteners, Inc]**

- 3) **<Insert manufacturer's name>**
 - c. Description: Self-locking washers formed from **0.016-inch- (0.41-mm-)** thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than **1-1/2 inches (38 mm)** in diameter.
 - C. Insulation Staples: Outward-clinching insulation staples, nominal **3/4 inch (19 mm)** wide, stainless steel or Monel.
 - D. Insulation Wire:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[C & F Wire Products]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[RPR Products, Inc.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[C & F Wire Products]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[RPR Products, Inc.]**
 - d. **<Insert manufacturer's name>**
 3. Description: **[0.080-inch (2.0-mm) nickel-copper alloy][0.062-inch (1.6-mm) soft-annealed, stainless steel][0.062-inch (1.6-mm) soft-annealed, galvanized steel]** .
- 2.20 INSULATION CORNER ANGLES
- A. Insulation Corner Angle - PVC:
 1. Thickness: Minimum **[30 mils (0.8 mm)]<Insert dimension>** .
 2. Dimensions: Minimum **1 by 1 inch (25 by 25 mm)**.
 3. Material: PVC in accordance with ASTM D1784, Class 16354-C, white or color-coded to match adjacent surface.
 - B. Insulation Corner Angle - Aluminum:
 1. Thickness: Minimum **[0.040 inch (1.0 mm)]<Insert dimension>** .
 2. Dimensions: Minimum **1 by 1 inch (25 by 25 mm)**.
 3. Material: Aluminum in accordance with **ASTM B209 (ASTM B209M)**, Alloy 3003, 3005, 3105, or 5005; Temper H-14.
 - C. Insulation Corner Angle - Stainless Steel:
 1. Thickness: **[0.024 inch (0.61 mm)]<Insert dimension>** .
 2. Dimensions: Minimum **1 by 1 inch (25 by 25 mm)**.
 3. Material: Stainless steel in accordance with ASTM A240/A240M, **[Type 304][or][Type 316]** .

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that equipment to be insulated has been tested and is free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer **5 mils (0.127 mm)** thick and an epoxy finish **5 mils (0.127 mm)** thick if operating in a temperature range of between **140 and 300 deg F (60 and 149 deg C)**. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 - 2. Carbon Steel: Coat carbon steel operating at a service temperature of between **32 and 300 deg F (0 and 149 deg C)** with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 INSTALLATION OF EQUIPMENT INSULATION, GENERAL

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.
- B. Install insulation materials, forms, vapor barriers or retarders, and jackets, of thicknesses required for each item of equipment, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in

accordance with the Contract Documents [, **unless otherwise approved by the Engineer-of-record**] .

- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 - 2. Cover circumferential joints with **3-inch- (75-mm-)** wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced **4 inches (100 mm)** o.c.
 - 3. Overlap jacket longitudinal seams at least **1-1/2 inches (38 mm)**. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at [**2 inches (50 mm)**][**4 inches (100 mm)**] o.c.
 - 4. For below-ambient services, apply vapor-barrier mastic over staples.
 - 5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 - 6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.
- L. Cut insulation in a manner to avoid compressing insulation.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least **4 inches (100 mm)** beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- O. For above-ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.
- P. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on **6-inch (150-mm)** centers, starting at corners. Install **3/8-inch- (10-mm-)** diameter fasteners with wing nuts. Alternatively, secure the box sections together using a field-adjustable latching mechanism.
2. Fabricate boxes from **[galvanized steel][aluminum][or][stainless steel]** , at least **[0.040 inch (1.0 mm)][0.050 inch (1.3 mm)][0.060 inch (1.6 mm)]** thick.
3. For below-ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.4 INSTALLATION OF MINERAL WOOL EQUIPMENT INSULATION

A. Secure mineral wool equipment insulation with adhesive, anchor pins, and speed washers.

1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for **[100][50]<Insert number>** percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Insulation Hangers and Speed Washers: Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing to be **3 inches (75 mm)** from insulation end joints and **16 inches (400 mm)** o.c. in both directions.
 - d. Do not compress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins, and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately **6 inches (150 mm)** from each end. Install wire or cable between two circumferential girdles **12 inches (300 mm)** o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of **48 inches (1200 mm)** o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least **3 inches (75 mm)**.
8. Install insulation in removable and replaceable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

3.5 INSTALLATION OF GLASS-FIBER EQUIPMENT INSULATION

- A. Secure glass-fiber equipment insulation with adhesive, anchor pins, and speed washers.
1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for **[100][50]<Insert number>** percent coverage of tank and vessel surfaces.
 2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 3. Protect exposed corners with secured corner angles.
 4. Insulation Hangers and Speed Washers: Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing to be **3 inches (75 mm)** from insulation end joints and **16 inches (400 mm)** o.c. in both directions.
 - d. Do not compress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins, and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - h. Secure each layer of insulation with stainless steel or aluminum bands. Select band material compatible with insulation materials.
 - i. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately **6 inches (150 mm)** from each end. Install wire or cable between two circumferential girdles **12 inches (300 mm)** o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of **48 inches (1200 mm)** o.c. Use this network for securing insulation with tie wire or bands.
 - j. Stagger joints between insulation layers at least **3 inches (75 mm)**.
 - k. Install insulation in removable and replaceable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
 - l. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
 - m. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

3.6 INSTALLATION OF CALCIUM-SILICATE EQUIPMENT INSULATION

- A. On Boiler Breechings:
1. Secure single-layer insulation with stainless steel bands at **12-inch (300-mm)** intervals, and tighten bands without deforming insulation material.
 2. Install two-layer insulation with joints tightly butted and staggered at least **3 inches (75 mm)**. Secure inner layer with wire spaced at **12-inch (300-mm)** intervals. Secure outer layer with stainless steel bands at **12-inch (300-mm)** intervals.
 3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive

and press on one layer of glass cloth. Overlap edges at least **1 inch (25 mm)**. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC EQUIPMENT INSULATION

- A. Install in accordance with manufacturer's written installation instructions and ASTM C1710.
- B. Apply **[100]<Insert value>** percent coverage of adhesive to surface with manufacturer's recommended adhesive.
- C. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Finish: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

3.8 INSTALLATION OF WOVEN GLASS-FIBER CLOTH FOR INSULATION

- A. Where woven glass-fiber jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - 1. Draw jacket smooth and tight to surface with **2-inch (50-mm)** overlap at seams and joints.
 - 2. Embed glass cloth between two **0.062-inch- (1.6-mm-)** thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.

3.9 INSTALLATION OF FIELD-APPLIED INSULATION JACKETS

- A. Insulation Jacket, Field Applied - FSK:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with **1-1/2-inch (38-mm)** laps at longitudinal seams and **3-inch- (75-mm-)** wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. Insulation Jacket, Field Applied - PVC:
 - 1. Install with **1-inch (25-mm)** overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
 - 2. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- C. Insulation Jacket, Field Applied - Metal:
 - 1. Install with **2-inch (50-mm)** overlap at longitudinal seams and end joints.
 - 2. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands **12 inches (300 mm)** o.c. and at end joints.

D. Insulation Jacket, Field Applied - PVDC:

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of **33-1/2 inches (850 mm)** or less. **33-1/2-inch- (850-mm-)** circumference limit allows for **2-inch- (50-mm-)** overlap seal.
2. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
3. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

E. Insulation Jacket, Field Applied - PVDC-SSL:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap presized jackets around individual pipe insulation sections, with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of **2 inches (50 mm)** over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of **33-1/2 inches (850 mm)** or less. The **33-1/2-inch- (850-mm-)** circumference limit allows for **2-inch- (50-mm-)** overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.10 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: **[Two]<Insert number>** finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless steel jackets.

3.11 FIELD QUALITY CONTROL

A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

- C. Perform tests and inspections [**with the assistance of a factory-authorized service representative**] .
- D. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to **[one]<Insert number>** location(s) for each type of equipment defined in "Indoor Equipment Insulation Schedule" and "Outdoor, Aboveground Equipment Insulation Schedule" articles. For large equipment, remove only a portion adequate to determine compliance.
- E. All insulation applications will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.12 BREECHING INSULATION SCHEDULE

- A. Round, Exposed Breeching and Connector Insulation: To be one of the following:
 - 1. Equipment Insulation - Calcium Silicate: **4 inches (100 mm)** thick.
 - 2. Equipment Insulation - High-Temperature Glass-Fiber Blanket: **3 inches (75 mm)** thick and **3 lb/cu. ft. (48 kg/cu. m)** nominal density.
 - 3. Equipment Insulation - Mineral Wool Blanket: **3 inches (75 mm)** thick and **4 lb/cu. ft. (64 kg/cu. m)** nominal density.
- B. Round, Concealed Breeching and Connector Insulation: To be one of the following:
 - 1. Equipment Insulation - Calcium Silicate: **4 inches (100 mm)** thick.
 - 2. Equipment Insulation - High-Temperature Glass-Fiber Blanket: **3 inches (75 mm)** thick and **3 lb/cu. ft. (48 kg/cu. m)** nominal density.
 - 3. Equipment Insulation - Mineral Wool Blanket: **3 inches (75 mm)** thick and **4 lb/cu. ft. (64 kg/cu. m)** nominal density.
- C. Rectangular, Exposed Breeching and Connector Insulation: To be one of the following:
 - 1. Equipment Insulation - Calcium Silicate: **4 inches (100 mm)** thick.
 - 2. Equipment Insulation - High-Temperature Glass-Fiber Blanket: **3 inches (75 mm)** thick and **3 lb/cu. ft. (48 kg/cu. m)** nominal density.
 - 3. Equipment Insulation - High-Temperature Glass-Fiber Board: **3 inches (75 mm)** thick and **[3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]** nominal density.
 - 4. Equipment Insulation - Mineral Wool Blanket: **3 inches (75 mm)** thick and **4 lb/cu. ft. (64 kg/cu. m)** nominal density.
 - 5. Equipment Insulation - Mineral Wool Board: **3 inches (75 mm)** thick and **[4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]** nominal density.
- D. Rectangular, Concealed Breeching and Connector Insulation: To be one of the following:
 - 1. Equipment Insulation - Calcium Silicate: **4 inches (100 mm)** thick.
 - 2. Equipment Insulation - High-Temperature Glass-Fiber Blanket: **3 inches (75 mm)** thick and **3 lb/cu. ft. (48 kg/cu. m)** nominal density.
 - 3. Equipment Insulation - High-Temperature Glass-Fiber Board: **3 inches (75 mm)** thick and **[3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]** nominal density.
 - 4. Equipment Insulation - Mineral Wool Blanket: **3 inches (75 mm)** thick and **[4 lb/cu. ft. (64 kg/cu. m)]<Insert density>** nominal density.
 - 5. Equipment Insulation - Mineral Wool Board: **3 inches (75 mm)** thick and **[4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]** nominal density.

3.13 INDOOR HVAC EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thickness are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment that is not factory insulated.
- C. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, condenser bundles, heat-recovery bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles with one of the following:
 - 1. Equipment Insulation - Cellular Glass: **[2 inches (50 mm)]<Insert dimension>** thick.
 - 2. Equipment Insulation - Flexible Elastomeric: **[1 inch (25 mm)]<Insert dimension>** thick.
 - 3. Equipment Insulation - Glass-Fiber Board: **[1 inch (25 mm)]<Insert dimension>** thick and **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]** nominal density.
 - 4. Equipment Insulation - Glass-Fiber, Pipe and Tank: **[1 inch (25 mm)]<Insert dimension>** thick.
 - 5. Equipment Insulation - Mineral Wool Board: **[1 inch (25 mm)]<Insert dimension>** thick and **[4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density>** nominal density.
 - 6. Equipment Insulation - Mineral Wool, Pipe and Tank: **[1.5 inches (38 mm)]<Insert dimension>** thick.
 - 7. Equipment Insulation - Polyisocyanurate: **[1 inch (25 mm)]<Insert dimension>** thick.
 - 8. Equipment Insulation - Polyolefin: **[1 inch (25 mm)]<Insert dimension>** thick.
- D. Heat-Exchanger (Water-to-Water for Cooling Service) Insulation: To be one of the following:
 - 1. Equipment Insulation - Cellular Glass: **[2 inches (50 mm)]<Insert dimension>** thick.
 - 2. Equipment Insulation - Flexible Elastomeric: **[1 inch (25 mm)]<Insert dimension>** thick.
 - 3. Equipment Insulation - Glass-Fiber Blanket: **[1 inch (25 mm)]<Insert dimension>** thick and **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]** nominal density.
 - 4. Equipment Insulation - Glass-Fiber Board: **[1 inch (25 mm)]<Insert dimension>** thick and **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]** nominal density.
 - 5. Equipment Insulation - Glass-Fiber, Pipe and Tank: **[1 inch (25 mm)]<Insert dimension>** thick.
 - 6. Equipment Insulation - Mineral Wool Blanket: **[1 inch (25 mm)]<Insert dimension>** thick and **[4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density>** nominal density.
 - 7. Equipment Insulation - Mineral Wool Board: **[1 inch (25 mm)]<Insert dimension>** thick and **[4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density>** nominal density.
 - 8. Equipment Insulation - Mineral Wool, Pipe and Tank: **[1.5 inches (38 mm)]<Insert dimension>** thick.
 - 9. Equipment Insulation - Polyisocyanurate: **[1 inch (25 mm)]<Insert dimension>** thick.
 - 10. Equipment Insulation - Polyolefin: **[1 inch (25 mm)]<Insert dimension>** thick.
- E. Heat-Exchanger (Water-to-Water for Heating Service) Insulation: To be one of the following:
 - 1. Equipment Insulation - Calcium Silicate: **[3 inches (75 mm)]<Insert dimension>** thick.
 - 2. Equipment Insulation - Cellular Glass: **[3 inches (75 mm)]<Insert dimension>** thick.
 - 3. Equipment Insulation - Glass-Fiber Blanket: **[2 inches (50 mm)]<Insert dimension>** thick and **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]** nominal density.
 - 4. Equipment Insulation - Glass-Fiber Board: **[2 inches (50 mm)]<Insert dimension>** thick and **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]** nominal density.
 - 5. Equipment Insulation - Glass-Fiber, Pipe and Tank: **[2 inches (50 mm)]<Insert dimension>** thick.
 - 6. Equipment Insulation - Mineral Wool Blanket: **[2 inches (50 mm)]<Insert dimension>** thick and **[4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density>** nominal density.
 - 7. Equipment Insulation - Mineral Wool Board: **[2 inches (50 mm)]<Insert dimension>** thick and **[4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density>** nominal density.
 - 8. Equipment Insulation - Mineral Wool, Pipe and Tank: **[2 inches (50 mm)]<Insert dimension>**

thick.

F. Steam-to-Steam Generator Insulation: To be one of the following:

1. Equipment Insulation - Calcium Silicate: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)][8 lb/cu. ft. (128 kg/cu. m)]<Insert density> nominal density.
6. Equipment Insulation - Mineral Wool, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.

G. Steam-to-Hot-Water Converter Insulation: To be one of the following:

1. Equipment Insulation - Calcium Silicate: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Blanket: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
5. Equipment Insulation - Glass-Fiber Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
6. Equipment Insulation - Mineral Wool Blanket: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)][8 lb/cu. ft. (128 kg/cu. m)]<Insert density> nominal density.
7. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)][8 lb/cu. ft. (128 kg/cu. m)]<Insert density> nominal density.
8. Equipment Insulation - Mineral Wool Pipe and Tank: [2 inches (38 mm)]<Insert dimension> thick.

H. Hot-Water-to-Steam Converter Insulation: To be one of the following:

1. Equipment Insulation - Calcium Silicate: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)][8 lb/cu. ft. (128 kg/cu. m)]<Insert density> nominal density.
6. Equipment Insulation - Mineral Wool Pipe and Tank: [2 inches (38 mm)]<Insert dimension> thick.

I. Chilled-Water Pump Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

J. Condenser-Water Pump Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [2 inches (50 mm)]<Insert dimension> thick.
2. Equipment Insulation - Glass-Fiber Board: [1 inch (25 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Equipment Insulation - Mineral Wool Board: [1 inch (25 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

K. Dual-Service Heating and Cooling Pump Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
4. Equipment Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.

L. Heating-Hot-Water Pump Insulation: To be one of the following:

1. Equipment Insulation - Calcium Silicate: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

M. Heat-Recovery Pump Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [2 inches (50 mm)]<Insert dimension> thick.
2. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

N. Steam Condensate Pump and Boiler Feedwater Pump Insulation: To be one of the following:

1. Equipment Insulation - Calcium Silicate: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)][8 lb/cu. ft. (128 kg/cu. m)]<Insert density> nominal density.
6. Equipment Insulation - Mineral Wool, Pipe and Tank: [2 inches (38 mm)]<Insert dimension> thick.

O. Chilled-Water Expansion/Compression Tank Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

6. Equipment Insulation - Mineral Wool, Pipe and Tank: [1.5 inches (38 mm)]<Insert dimension> thick.
7. Equipment Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
8. Equipment Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.

P. Condenser-Water Expansion/Compression Tank Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [2 inches (50 mm)]<Insert dimension> thick.
2. Equipment Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [1 inch (25 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber Pipe and Tank: [1 inch (25 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [1 inch (25 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
6. Equipment Insulation - Mineral Wool Pipe and Tank: [1.5 inches (38 mm)]<Insert dimension> thick.
7. Equipment Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
8. Equipment Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.

Q. Dual-Service Heating and Cooling Expansion/Compression Tank Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [2 inches (50 mm)]<Insert dimension> thick.
2. Equipment Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [2 inch (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber Pipe and Tank: [2 inch (50 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [2 inch (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
6. Equipment Insulation - Mineral Wool, Pipe and Tank: [2 inch (50 mm)]<Insert dimension> thick.
7. Equipment Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
8. Equipment Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.

R. Heating-Hot-Water Expansion/Compression Tank Insulation: To be one of the following:

1. Equipment Insulation - Calcium Silicate: [2 inches (50 mm)]<Insert dimension> thick.
2. Equipment Insulation - Cellular Glass: [2 inches (50 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
6. Equipment Insulation - Mineral Wool, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.

S. Heat-Recovery Expansion/Compression Tank Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [2 inches (50 mm)]<Insert dimension> thick.
2. Equipment Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [1 inch (25 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber, Pipe and Tank: [1 inch (25 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [1 inch (25 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
6. Equipment Insulation - Mineral Wool, Pipe and Tank: [1.5 inches (38 mm)]<Insert dimension> thick.

7. Equipment Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
 8. Equipment Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- T. Chilled-Water Air-Separator Insulation: To be one of the following:
1. Equipment Insulation - Cellular Glass: [2 inches (50 mm)]<Insert dimension> thick.
 2. Equipment Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 3. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Equipment Insulation - Glass-Fiber, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
 5. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Equipment Insulation - Mineral Wool, Pipe and Tank: [1.5 inches (38 mm)]<Insert dimension> thick.
 7. Equipment Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
 8. Equipment Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- U. Condenser-Water Air-Separator Insulation: To be one of the following:
1. Equipment Insulation - Cellular Glass: [2 inches (50 mm)]<Insert dimension> thick.
 2. Equipment Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 3. Equipment Insulation - Glass-Fiber Board: [1 inch (25 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Equipment Insulation - Glass-Fiber, Pipe and Tank: [1 inch (25 mm)]<Insert dimension> thick.
 5. Equipment Insulation - Mineral Wool Board: [1 inch (25 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Equipment Insulation - Mineral Wool, Pipe and Tank: [1.5 inches (38 mm)]<Insert dimension> thick.
 7. Equipment Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
 8. Equipment Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- V. Dual-Service Heating and Cooling Air-Separator Insulation: To be one of the following:
1. Equipment Insulation - Cellular Glass: [2 inches (50 mm)]<Insert dimension> thick.
 2. Equipment Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 3. Equipment Insulation - Glass-Fiber Board: [2 inches (250 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Equipment Insulation - Glass-Fiber, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
 5. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 6. Equipment Insulation - Mineral Wool, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
 7. Equipment Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
 8. Equipment Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- W. Heating-Hot-Water Air-Separator Insulation: To be one of the following:
1. Equipment Insulation - Calcium Silicate: [3 inches (75 mm)]<Insert dimension> thick.
 2. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
 3. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
 4. Equipment Insulation - Glass-Fiber, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
 5. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4

lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.

6. Equipment Insulation - Mineral Wool, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.

X. Heat-Recovery Air-Separator Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [2 inches (50 mm)]<Insert dimension> thick.
2. Equipment Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [1 inch (25 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber, Pipe and Tank: [1 inch (25 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
6. Equipment Insulation - Mineral Wool, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
7. Equipment Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
8. Equipment Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.

Y. Thermal Storage Tank (Brine, Water, Ice) Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [4 inches (100 mm)]<Insert dimension> thick.
2. Equipment Insulation - Glass-Fiber Board: [3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Equipment Insulation - Glass-Fiber, Pipe and Tank: [3 inches (75 mm)]<Insert dimension> thick.
4. Equipment Insulation - Mineral Wool Board: [3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)][8 lb/cu. ft. (128 kg/cu. m)]<Insert density> nominal density.
5. Equipment Insulation - Mineral Wool, Pipe and Tank: [3 inches (75 mm)]<Insert dimension> thick.
6. Equipment Insulation - Polyisocyanurate (Outdoor Application Only): [3 inches (75 mm)]<Insert dimension> thick.
7. Equipment Insulation - Polystyrene (Outdoor Application Only): [3 inches (75 mm)]<Insert dimension> thick.

Z. Deaerator Insulation: To be one of the following:

1. Equipment Insulation - Calcium Silicate: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [3 inches (75 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber, Pipe and Tank: [3 inches (75 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [3 inches (75 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)][8 lb/cu. ft. (128 kg/cu. m)]<Insert density> nominal density.
6. Equipment Insulation - Mineral Wool, Pipe and Tank: [3 inches (75 mm)]<Insert dimension> thick.

AA. Steam Condensate Tank and Receiver Insulation: To be one of the following:

1. Equipment Insulation - Calcium Silicate: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.

4. Equipment Insulation - Glass-Fiber, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
6. Equipment Insulation - Mineral Wool, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.

BB. Steam Flash-Tank, Flash-Separator, Moisture-Separator, and Blow-Off-Tank Insulation: To be one of the following:

1. Equipment Insulation - Calcium Silicate: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
3. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
4. Equipment Insulation - Glass-Fiber, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
5. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)][8 lb/cu. ft. (128 kg/cu. m)]<Insert density> nominal density.
6. Equipment Insulation - Mineral Wool, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.

CC. Piping System Filter-Housing Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Equipment Insulation - Glass-Fiber, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
4. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
5. Equipment Insulation - Mineral Wool, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.

3.14 OUTDOOR, ABOVEGROUND EQUIPMENT INSULATION SCHEDULE

A. Heated, Fuel-Oil Storage Tank Insulation: To be one of the following:

1. Equipment Insulation - Cellular Glass: [3 inches (75 mm)]<Insert dimension> thick.
2. Equipment Insulation - Glass-Fiber Board: [2 inches (50 mm)]<Insert dimension> thick and [2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.
3. Equipment Insulation - Glass-Fiber, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
4. Equipment Insulation - Mineral Wool Board: [2 inches (50 mm)]<Insert dimension> thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
5. Equipment Insulation - Mineral Wool, Pipe and Tank: [2 inches (50 mm)]<Insert dimension> thick.
6. Equipment Insulation - Polyisocyanurate: [1-1/2 inches (38 mm)]<Insert dimension> thick.

3.15 INDOOR, FIELD-APPLIED INSULATION JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Equipment, Concealed from View:
1. None.
 2. PVC: **[Standard][Color-coded by system]** .
 - a. Thickness: **[20 mils (0.5 mm)][30 mils (0.8 mm)]** .
 3. Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
 4. Painted Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)]** .
 5. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth No. 2B finish][corrugated][stucco embossed]** .
 - a. Thickness: **[0.010 inch (0.25 mm)][0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .
- D. Equipment, Exposed to View, up to 48 inches (1200 mm) in Diameter or with Flat Surfaces of up to 72 Inches (1800 mm):
1. None.
 2. Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
 3. Painted Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)]** .
 4. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth No. 2B finish][corrugated][stucco embossed]** .
 - a. Thickness: **[0.010 inch (0.25 mm)][0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .
- E. Equipment, Exposed to View, Larger Than 48 inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
1. None.
 2. Aluminum: **[Smooth][Stucco embossed]** with **[1-1/4-inch- (32-mm-) deep corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs]** .
 - a. Thickness: **[0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .

3. Painted Aluminum: **[Smooth][Stucco embossed]** with **[1-1/4-inch- (32-mm-) deep corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs]** .
 - a. Thickness: **[0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
4. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth][stucco embossed]** , with **[1-1/4-inch- (32-mm-) deep corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs]** .
 - a. Thickness: **[0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .

3.16 OUTDOOR, FIELD-APPLIED INSULATION JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Equipment, Concealed from View:
 1. None.
 2. PVC: **[Standard][Color-coded by system]** .
 - a. Thickness: **[20 mils (0.5 mm)][30 mils (0.8 mm)]** .
 3. Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
 4. Painted Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)]** .
 5. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth No. 2B finish][corrugated][stucco embossed]** .
 - a. Thickness: **[0.010 inch (0.25 mm)][0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .
- D. Equipment, Exposed to View, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces of up to 72 Inches (1800 mm):
 1. None.
 2. Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
 3. Painted Aluminum: **[Smooth][Corrugated][Stucco embossed][, with Z-shaped locking seam]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032**



inch (0.81 mm)][0.040 inch (1.0 mm)] .

4. Stainless Steel: [Type 304][or][Type 316] , [smooth No. 2B finish][corrugated][stucco embossed][, with Z-shaped locking seam] .

- a. Thickness: [0.020 inch (0.51 mm)][0.024 inch (0.61 mm)] .

- E. Equipment, Exposed to View, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):

1. None.
 2. Aluminum: [Smooth][Stucco embossed] with [1-1/4-inch- (32-mm-) deep corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs] .

- a. Thickness: [0.032 inch (0.81 mm)][0.040 inch (1.0 mm)] .

3. Painted Aluminum: [Smooth][Stucco embossed] with [1-1/4-inch- (32-mm-) deep corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs] .

- a. Thickness: [0.032 inch (0.81 mm)][0.040 inch (1.0 mm)] .

4. Stainless Steel: [Type 304][or][Type 316] , [smooth][stucco embossed] , with [1-1/4-inch- (32-mm-) deep corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs] .

- a. Thickness: [0.020 inch (0.51 mm)][0.024 inch (0.61 mm)] .

END OF SECTION 23 07 16 00



SECTION 23 07 19 00 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Calcium-silicate pipe insulation.
2. Cellular-glass pipe insulation.
3. Flexible elastomeric pipe insulation.
4. Glass-fiber pipe insulation.
5. Mineral wool pipe insulation.
6. Phenolic pipe insulation.
7. Polyisocyanurate pipe insulation.
8. Polyolefin pipe insulation.
9. Polystyrene pipe insulation.
10. Insulating cements.
11. Insulation adhesives.
12. Insulation mastics and coatings.
13. Insulation sealants.
14. Field-applied insulation jackets.
15. Field-applied fabric reinforcing mesh for insulation.
16. Field-applied cloths for insulation.
17. Vapor-retarder tapes.
18. Insulation securements.

B. Related Requirements:

1. Section 230713 "Duct Insulation" for duct insulation.
2. Section 230716 "HVAC Equipment Insulation" for equipment insulation.
3. Section 232113.13 "Underground Hydronic Piping" for loose-fill pipe insulation in underground piping outside the building.
4. Section 232213.13 "Underground Steam and Condensate Heating Piping" for steam and condensate piping for steam-type tank heaters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of specified product. Include thermal conductivity, water-vapor permeance, thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings:

1. Include plans, elevations, sections, details, and attachment details.
2. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
3. Detail attachment and covering of heat tracing inside insulation.
4. Detail insulation application at pipe expansion joints for each type of insulation.
5. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
6. Detail removable insulation at piping specialties.
7. Detail application of field-applied jackets.

8. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Preformed Pipe Insulation Materials: **12 inches (300 mm)** long by **NPS 2 (DN 50)**.
2. Sheet Form Insulation Materials: **12 inches (300 mm)** square.
3. Jacket Materials for Pipe: **12 inches (300 mm)** long by **NPS 2 (DN 50)**.
4. Sheet Jacket Materials: **12 inches (300 mm)** square.
5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating percentage of postconsumer and preconsumer recycled content and cost.
2. Environmental Product Declaration (EPD): For each product.
3. Health Product Declaration (HPD): For each product.
4. Environmental Product Declaration (EPD): For each product.
5. Health Product Declaration (HPD): For each product.
6. Environmental Product Declaration (EPD): For each product.
7. Environmental Product Declaration (EPD): For each product.
8. Environmental Product Declaration (EPD): For each product.
9. Third-Party Certifications: For each product.
10. Third-Party-Certified Life-Cycle Assessment: For each product.
11. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
12. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

1.3 INFORMATIONAL SUBMITTALS

- A. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- B. Field Quality Control Reports: For specified tests and inspections.
- C. Qualification Statements: For Installer.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program [, **certified by the Department of Labor, Bureau of Apprenticeship and Training**] .

1.5 MOCKUPS

- A. Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Piping Mockups:
 - a. One **10-ft. (3-m)** section of **NPS 2 (DN 50)** straight pipe.
 - b. One each of a 90-degree threaded, welded, and flanged elbow.
 - c. One each of a threaded, welded, and flanged tee fitting.
 - d. One **NPS 2 (DN 50)** or smaller valve and one **NPS 2-1/2 (DN 65)** or larger valve.
 - e. Four support hangers, including hanger shield and insert.
 - f. One threaded strainer and one flanged strainer with removable portion of insulation.
 - g. One threaded reducer and one welded reducer.
 - h. One pressure temperature tap.
 - i. One mechanical coupling.
 - j. One union.
2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
3. Notify Architect [**seven**]**<Insert number>** days in advance of dates and times when mockups will be constructed.
4. Obtain Architect's approval of mockups before starting insulation application.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation system materials are to be delivered to Project site in unopened containers. The packaging is to include name of manufacturer, fabricator, type, description, and size [, **as well as ASTM standard designation, and maximum use temperature**] .

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems [**and after installing and testing heat tracing**] . Insulation application may begin on segments that have satisfactory test results.



PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authority having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 3. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 PIPING INSULATION MATERIALS, GENERAL

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials are applied.
- B. Products are not to contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel are to have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel are to be qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials are not to use CFC or HCFC blowing agents in the manufacturing process.

2.3 CALCIUM-SILICATE PIPE INSULATION

- A. Pipe Insulation - Calcium Silicate, Preformed:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Aeroflex USA]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[TPS Industrial; a trademark of Chase Manufacturing, Inc.]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aeroflex USA]**

- b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[TPS Industrial; a trademark of Chase Manufacturing, Inc.]**
 - d. **<Insert manufacturer's name>**
- 3. Description: ASTM C533, flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement, Type I.
 - 4. Standard: ASTM C533, Type I.
 - 5. Prefabricated Fitting Covers: ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.4 CELLULAR-GLASS PIPE INSULATION

A. Pipe Insulation - Cellular Glass, Preformed:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Owens Corning]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Owens Corning]**
 - b. **<Insert manufacturer's name>**
- 3. Description: Preformed cellular glass pipe insulation of inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells.
- 4. Standard: ASTM C552.
- 5. Fabricated shapes in accordance with ASTM C450, ASTM C585, and ASTM C1639.
- 6. Without Insulation Facing: Type II, Class 1.
- 7. Factory-Applied Insulation Facing: Type II, Class 2.
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 - b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 - c. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
 - d. PSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.5 FLEXIBLE ELASTOMERIC PIPE INSULATION

A. Pipe Insulation - Flexible Elastomeric:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**
 - c. **[K-Flex USA]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**
 - c. **[K-Flex USA]**
 - d. **<Insert manufacturer's name>**
3. Description: Closed-cell or expanded-rubber flexible elastomeric pipe insulation.
4. Standard: ASTM C534/C534M, Type I, for tubular materials; Type II for sheet materials.
5. Suitable for maximum use temperature between **minus 70 deg F (minus 57 deg C)** and **plus 220 deg F (plus 104 deg C)**.

2.6 GLASS-FIBER PIPE INSULATION**A. Pipe Insulation - Glass-Fiber, Preformed:**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[Knauf Insulation]**
 - c. **[Manson Insulation Inc.]**
 - d. **[Owens Corning]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[Knauf Insulation]**
 - c. **[Manson Insulation Inc.]**
 - d. **[Owens Corning]**
 - e. **<Insert manufacturer's name>**
3. Description: Glass fibers bonded with a thermosetting resin.
4. Suitable for maximum use temperature up to **850 deg F (454 deg C)** in accordance with ASTM C411. Comply with ASTM C547.
5. Preformed Pipe Insulation: Type I, Grade A.
6. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
7. Unfaced.
8. Factory-Applied Insulation Facing:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.

- b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
- c. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
- d. PSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

B. Pipe Insulation - Glass-Fiber, Pipe and Tank:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Manson Insulation Inc.]**
 - e. **[Owens Corning]**
 - f. **<Insert manufacturer's name>**
- 3. Description: Glass fibers bonded with a thermosetting resin.
- 4. Standard: ASTM C1393.
- 5. Suitable for use temperature between **35 deg F (1.7 deg C) and 850 deg F (454 deg C)**, in accordance with ASTM C411.
- 6. Semirigid board material.
- 7. Factory-Applied Insulation Facing:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 - b. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type III.
 - c. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
 - d. PSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.7 MINERAL WOOL PIPE INSULATION

A. Pipe Insulation - Mineral Wool, Preformed:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [Johns Manville; a Berkshire Hathaway company]
- b. [Owens Corning]
- c. [ROCKWOOL]
- d. <Insert manufacturer's name>

- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Johns Manville; a Berkshire Hathaway company]
- b. [Owens Corning]
- c. [ROCKWOOL]
- d. <Insert manufacturer's name>

- 3. Description: Mandrel-wound mineral wool fibers bonded with a thermosetting resin, unfaced; suitable for maximum use temperature up to **1200 deg F (650 deg C)** in accordance with ASTM C447.

- 4. Standard: ASTM C547.

- 5. Preformed Pipe Insulation: Type II, Grade A.

- 6. Fabricated shapes in accordance with ASTM C450 and ASTM C585.

- 7. Unfaced.

- 8. Factory-Applied Insulation Facing:

- a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
- b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
- c. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
- d. PSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

B. Pipe Insulation - Mineral Wool, Pipe and Tank:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [Johns Manville; a Berkshire Hathaway company]
- b. [Owens Corning]
- c. [ROCKWOOL]
- d. <Insert manufacturer's name>

- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Johns Manville; a Berkshire Hathaway company]
- b. [Owens Corning]

- c. **[ROCKWOOL]**
- d. **<Insert manufacturer's name>**
- 3. Description: Mineral wool fibers bonded with a thermosetting resin.
- 4. Standard: ASTM C1393.
- 5. Suitable for maximum use temperature up to **1000 deg F (538 deg C)**, in accordance with ASTM C411.
- 6. Semirigid board material.
- 7. Factory-Applied Insulation Facing:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 - b. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type III.
 - c. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
 - d. PSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.8 PHENOLIC PIPE INSULATION

A. Pipe Insulation - Phenolic:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[Kingspan Tarec Industrial Insulation NV]**
 - c. **[Polyguard Products, Inc.]**
 - d. **[Resolco Inc.]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[Kingspan Tarec Industrial Insulation NV]**
 - c. **[Polyguard Products, Inc.]**
 - d. **[Resolco Inc.]**
 - e. **<Insert manufacturer's name>**
- 3. Description: Prefabricated phenolic pipe insulation of rigid, expanded, closed-cell structure.
- 4. Standard: ASTM C1126.
- 5. Prefabricated Pipe Insulation: Type III.
- 6. Prefabricated shapes in accordance with ASTM C450 and ASTM C585.
- 7. Unfaced.
- 8. Factory-Applied Insulation Facing:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 - b. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with

an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.

- c. PSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.9 POLYISOCYANURATE PIPE INSULATION

A. Pipe Insulation - Polyisocyanurate:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Duna USA Inc.]**
 - b. **[Dyplast Products]**
 - c. **[Johns Manville; a Berkshire Hathaway company]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Duna USA Inc.]**
 - b. **[Dyplast Products]**
 - c. **[Johns Manville; a Berkshire Hathaway company]**
 - d. **<Insert manufacturer's name>**
3. Description: Prefabricated, rigid cellular polyisocyanurate pipe insulation intended for use as thermal insulation.
4. Standard: ASTM C591.
5. Type IV, except thermal conductivity (k-value) to not exceed **0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C)** after 180 days of aging.
6. Flame-spread index is to be 25 or less, and smoke-developed index is to be 50 or less for thicknesses of up to **1.5 inch (38 mm)** as tested in accordance with ASTM E84.
7. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
8. Unfaced.
9. Factory-Applied Insulation Facing:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 - b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

2.10 POLYOLEFIN PIPE INSULATION

A. Pipe Insulation - Polyolefin:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[Armacell LLC]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armacell LLC]**
 - b. **<Insert manufacturer's name>**
3. Description: Polyethylene-type of polyolefin thermal plastic pipe insulation.
4. Standard: ASTM C1427, Type I, Grade 1, for tubular materials and Type II, Grade 1, for sheet materials [, **self-seal**] .

2.11 POLYSTYRENE PIPE INSULATION

A. Pipe Insulation - Polystyrene:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Dow Chemical Co., sold through Polyguard Products, Inc.]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dow Chemical Co., sold through Polyguard Products, Inc.]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **<Insert manufacturer's name>**
3. Description: Rigid, extruded cellular polystyrene intended for use as thermal insulation.
4. Standard: ASTM C578, Type I-XII for board or Type XIII for pipe insulation, except thermal conductivity (k-value) does not exceed **0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K)** after 180 days of aging.
5. Fabricate shapes in accordance with ASTM C450 and ASTM C585.

2.12 INSULATING CEMENTS

A. Insulating Cement for Glass Fiber and Mineral Wool:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Ramco Insulation, Inc.]**
 - b. **<Insert manufacturer's name>**



2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Ramco Insulation, Inc.]**
- b. **<Insert manufacturer's name>**

3. Standard: ASTM C195.

B. Insulating Cement for Expanded or Exfoliated Vermiculite:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[Ramco Insulation, Inc.]**
- b. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Ramco Insulation, Inc.]**
- b. **<Insert manufacturer's name>**

3. Standard: ASTM C196.

C. Hydraulic-Setting Insulating and Finishing Cement for Glass Fiber and Mineral Wool:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[Ramco Insulation, Inc.]**
- b. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Ramco Insulation, Inc.]**
- b. **<Insert manufacturer's name>**

3. Standard: ASTM C449.

2.13 INSULATION ADHESIVES

- A. Materials are to be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

- B. Insulation Adhesive for Lagging Cloth:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Vimasco Corporation]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Vimasco Corporation]**
 - d. **<Insert manufacturer's name>**
 3. Standard: MIL-A-3316C, Class I, Grade A.
 4. Adhesives to be compatible with insulation materials, jackets, and substrates.
 5. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
 6. Service Temperature Range: **[Plus 20 to 180 deg F (Minus 6 to plus 82 deg C)][0 to plus 180 deg F (Minus 18 to plus 82 deg C)]** .
 7. Color: White.
 8. Verify adhesive is as recommended by insulation manufacturer and has a VOC content of **[50]<Insert number>** g/L or less.
- C. Insulation Adhesive for Calcium Silicate:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **[Vimasco Corporation]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **[Vimasco Corporation]**
 - e. **<Insert manufacturer's name>**
 3. Description: Fibrous, sodium-silicate-based adhesive with a service temperature range of **50 to 800 deg F (10 to 427 deg C)**.
 4. Adhesive: As recommended by adhesive manufacturer and with a VOC content of 80 g/L or less.

D. Insulation Adhesive for Cellular Glass:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
3. Adhesive: As recommended by cellular-glass manufacturer and with a VOC content of 80 g/L or less.

E. Insulation Adhesive for Phenolic and Polyisocyanurate:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
3. Description: Solvent-based resin adhesive, with a service temperature range of **minus 75 to plus 300 deg F (minus 59 to plus 149 deg C)**.
4. Adhesive: As recommended by phenolic and polyisocyanurate manufacturer and with a VOC content of 50 g/L or less.

F. Insulation Adhesive, Solvent Based for Flexible Elastomeric and Polyolefin:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**

- c. **[Foster Brand; H. B. Fuller]**
 - d. **[K-Flex USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**
 - c. **[Foster Brand; H. B. Fuller]**
 - d. **[K-Flex USA]**
 - e. **<Insert manufacturer's name>**
3. Adhesive: As recommended by flexible elastomeric and polyolefin manufacturer and with a VOC content of **[80]<Insert value>** g/L or less.
4. Description: Solvent-based adhesive for flexible elastomeric and polyolefin insulation.
5. Flame-spread index is to be 25 or less and smoke-developed index is to be 50 or less as tested in accordance with ASTM E84.
6. Wet Flash Point: Below **0 deg F (minus 18 deg C)**.
7. Service Temperature Range: **40 to 200 deg F (4 to 93 deg C)**.
8. Color: **[Black]<Insert color>** .
- G. Insulation Adhesive for Glass Fiber and Mineral Wool:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
- a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Standard: MIL-A-3316C, Class 2, Grade A.
4. Adhesive: As recommended by mineral-fiber manufacturer and with a VOC content of 80 g/L or less.
5. Verify fiberglass adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).
- H. Insulation Adhesive for Polystyrene:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
3. Description: Solvent- or water-based, synthetic resin adhesive with a service temperature range of **minus 20 to plus 140 deg F (minus 29 to plus 60 deg C)**.
4. Adhesive: As recommended by polystyrene manufacturer and with a VOC content of 50 g/L or less.

I. Insulation Adhesive for ASJ, FSK, and PVDC Facings/Jackets:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Description: Insulation adhesive for bonding ASJ, FSK, and PVDC facing/jacket insulation lap seams and joints.
4. Standard: MIL-A-3316C, Class 2, Grade A.
5. Verify adhesives have a VOC content of 80 g/L or less.
6. Verify adhesives have a VOC content of 80 g/L or less.

J. Insulation Adhesive for PVC Jackets:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[P.I.C. Plastics, Inc.]**
 - c. **[Proto Corporation]**
 - d. **[Sekisui Voltek, LLC]**

- e. **[Speedline Corporation]**
 - f. **[The Dow Chemical Company]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **[P.I.C. Plastics, Inc.]**
 - c. **[Proto Corporation]**
 - d. **[Sekisui Voltek, LLC]**
 - e. **[Speedline Corporation]**
 - f. **[The Dow Chemical Company]**
 - g. **<Insert manufacturer's name>**
3. Adhesive: As recommended by PVC jacket manufacturer and with a VOC content of 50 g/L or less.
4. Description: PVC jacket adhesive to be compatible with and as recommended in writing in PVC jacket manufacturer's literature.

2.14 INSULATION MASTICS AND COATINGS

- A. Materials are to be compatible with insulation materials, jackets, and substrates.
- 1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.
 - 2. VOC Content: 300 g/L or less.
 - 3. Low-Emitting Materials: Verify mastic coatings comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 4. VOC Content: 300 g/L or less.
 - 5. Low-Emitting Materials: Verify mastic coatings comply with requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - 6. VOC Emissions: Verify mastic coatings contain no more than half of the chronic REL of VOCs when tested in accordance with the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.
 - 7. Verify mastics comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 8. Verify mastics comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - 9. Verify mastics comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.
- B. Insulation Vapor-Retarder Mastic - Water Based, Indoor Use:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Aeroflex USA]**
 - b. **[Childers Brand; H. B. Fuller Construction Products]**
 - c. **[Knauf Insulation]**
 - d. **[Vimasco Corporation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aeroflex USA]**
 - b. **[Childers Brand; H. B. Fuller Construction Products]**
 - c. **[Knauf Insulation]**
 - d. **[Vimasco Corporation]**
 - e. **<Insert manufacturer's name>**
3. Description: Insulation vapor-retarder mastic, water based, suitable for indoor use on below-ambient services.
4. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
5. Service Temperature Range: **[0 to plus 180 deg F (Minus 18 to plus 82 deg C)][Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C)]** .
6. Standard: MIL-PRF-19565C, Type II, for permeance requirements **[, with supplier listing on DOD QPD - Qualified Products Database]** .
7. Color: **[White]<Insert color>** .

C. Insulation Vapor-Retarder Mastic - Solvent Based, Indoor Use:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Description: Insulation vapor-retarder mastic, solvent based, suitable for indoor use on below-ambient services.
4. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
5. Service Temperature Range: **0 to 180 deg F (Minus 18 to plus 82 deg C)**.

6. Color: **[White]<Insert color>** .

D. Insulation Vapor-Retarder Mastic - Solvent Based, Outdoor Use:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Description: Insulation vapor-retarder mastic, solvent based, suitable for outdoor use on below-ambient services.
4. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
5. Service Temperature Range: **Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).**
6. Color: **[White]<Insert color>** .

E. Insulation Breather Mastic - Water Based, Indoor/Outdoor:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Knauf Insulation]**
 - d. **[Mon-Eco Industries, Inc.]**
 - e. **[Vimasco Corporation]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Knauf Insulation]**
 - d. **[Mon-Eco Industries, Inc.]**
 - e. **[Vimasco Corporation]**
 - f. **<Insert manufacturer's name>**
3. Description: Insulation breather mastic, water based, suitable for indoor and outdoor use on above-ambient surfaces.

4. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm (0.66 metric perm) at manufacturer's recommended dry film thickness.
5. Service Temperature Range: [0 to plus 180 deg F (Minus 18 to plus 82 deg C)][Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C)] .
6. Color: [White]<Insert color> .
7. Verify adhesive is as recommended by insulation manufacturer and has a VOC content of [50]<Insert number> g/L or less.

2.15 INSULATION SEALANTS

A. Insulation Joint Sealant:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. [Owens Corning]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. [Owens Corning]
 - e. <Insert manufacturer's name>
3. Permanently flexible, elastomeric sealant.
 - a. Service Temperature Range: [Minus 150 to plus 250 deg F (Minus 101 to plus 121 deg C)][Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C)] .
 - b. Color: White or gray.
4. Sealant shall have a VOC content of 420 g/L or less.

B. Flashing Sealant for FSK and Metal Jackets:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Mon-Eco Industries, Inc.]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Mon-Eco Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Flashing sealant to be compatible with insulation materials, jackets, and substrates.
 4. Fire- and water-resistant, flexible, elastomeric sealant.
 5. Service Temperature Range: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)**.
 6. Color: Aluminum.
 7. Sealant shall have a VOC content of 420 g/L or less.

C. Flashing Sealant for ASJ, PVDC, and PVC Jackets:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **<Insert manufacturer's name>**
3. Flashing sealant to be compatible with insulation materials, jackets, and substrates.
4. Fire- and water-resistant, flexible, elastomeric sealant.
5. Service Temperature Range: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)**.
6. Color: White.
7. Sealant shall have a VOC content of 420 g/L or less.

2.16 FIELD-APPLIED INSULATION JACKETS

- A. Field-applied jackets are to comply with ASTM C1136, Type I, unless otherwise indicated.
- B. Insulation Jacket, Field Applied - FSK:
 1. Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. Pipe Insulation Jacket, Field Applied - PVC:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Airex Manufacturing Inc.]**

- b. [Johns Manville; a Berkshire Hathaway company]
 - c. [P.I.C. Plastics, Inc.]
 - d. [Proto Corporation]
 - e. [Speedline Corporation]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Airex Manufacturing Inc.]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [P.I.C. Plastics, Inc.]
 - d. [Proto Corporation]
 - e. [Speedline Corporation]
 - f. <Insert manufacturer's name>
 3. Description: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C.
 4. Thickness: As indicated in "Outdoor, Field-Applied Insulation Jacket Schedule" Article under Part 3.
 5. Jacket: Roll stock ready for shop or field cutting and forming.
 6. Adhesive: As recommended in writing by jacket material manufacturer.
 7. Color: [White][Color-code jackets based on system. Color as selected by Architect] .
 8. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, and mechanical joints.
- D. Insulation Jacket, Field Applied - Metal:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [RPR Products, Inc.]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [RPR Products, Inc.]
 - c. <Insert manufacturer's name>
 3. Jacket Material - Aluminum:
 - a. Description: [Sheet and roll stock ready for shop or field sizing][Factory cut and rolled to size] .
 - b. Standard: **ASTM B209 (ASTM B209M)**, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - c. Finish and Thickness: As indicated in "Indoor, Field-Applied Insulation Jacket Schedule" and "Outdoor, Field-Applied Insulation Jacket Schedule" articles under Part 3.

- d. Moisture Barrier for Indoor Applications: **[1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][53-mil- (0.075-mm-) thick polysurlyn]** .
 - e. Moisture Barrier for Outdoor Applications: **[3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick polysurlyn]** .
 - f. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
4. Jacket Material - Stainless Steel:
- a. Description: **[Sheet and roll stock ready for shop or field sizing][Factory cut and rolled to size]** .
 - b. Standard: ASTM A240/A240M.
 - c. Material Type, Finish, and Thickness: As indicated in "Indoor, Field-Applied Insulation Jacket Schedule" and "Outdoor, Field-Applied Insulation Jacket Schedule" articles under Part 3.
 - d. Moisture Barrier for Indoor Applications: **[1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick polysurlyn]** .
 - e. Moisture Barrier for Outdoor Applications: **[3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper][3-mil- (0.075-mm-) thick polysurlyn]** .
 - f. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- E. Underground Direct-Buried Jacket:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Owens Corning]**
 - b. **[Polyguard Products, Inc.]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Owens Corning]**



- b. **[Polyguard Products, Inc.]**
- c. **<Insert manufacturer's name>**

- 3. Description: Underground direct-buried jacket of rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
- 4. Vapor Barrier and Waterproofing Membrane: **125 mils (3.2 mm)** thick.

F. Insulation Jacket, Field Applied - Outdoor, Self Adhesive (Asphaltic):

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[MFM Building Products Corp.]**
 - b. **[Polyguard Products, Inc.]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[MFM Building Products Corp.]**
 - b. **[Polyguard Products, Inc.]**
 - c. **<Insert manufacturer's name>**
- 3. Description: Self-adhesive outdoor asphaltic jacket of rubberized bituminous resin on a cross-laminated polyethylene film covered with **[white][stucco-embossed]** aluminum-foil.
- 4. Vapor Barrier and Waterproofing Membrane: **60 mils (1.5 mm)** thick.

G. Insulation Jacket, Field Applied - Indoor/Outdoor, Self Adhesive (Non-Asphaltic):

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[3M]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[3M]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - d. **<Insert manufacturer's name>**
- 3. Description: Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors.
- 4. Specialized jacket consisting of five layers of laminated aluminum and polyester film.
- 5. Adhesive Lap: Self-adhesive, low-temperature acrylic, pressure-sensitive adhesive lap.

6. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
7. Flame-Spread/Smoke-Developed Index: Flame-spread index of 25 and a smoke-developed index of 50 as tested in accordance with ASTM E84.
8. Aluminum Finish: **[Embossed][Smooth]** .
9. Outer Aluminum Surface: Coated with UV-resistant coating for protection from environmental contaminants.

H. Insulation Jacket, Field Applied - Indoor, PVDC:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
3. Description: PVDC jacket for indoor applications with white PVDC biaxially oriented barrier film.
4. Vapor Barrier and Waterproofing Membrane: **4 mils (0.10 mm)** thick.
5. Permeance: **0.02 perm (0.013 metric perm)** as tested in accordance with ASTM E96/E96M.
6. Flame-Spread/Smoke-Developed Index: Flame-spread index of 10 and a smoke-developed index of 20 when tested in accordance with ASTM E84.

I. Insulation Jacket, Field Applied - Outdoor, PVDC:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
3. Description: PVDC jacket for outdoor applications with white PVDC biaxially oriented barrier film.
4. Vapor Barrier and Waterproofing Membrane: **6 mils (0.15 mm)** thick.
5. Permeance: **0.01 perm (0.007 metric perm)** as tested in accordance with ASTM E96/E96M.
6. Flame-Spread/Smoke-Developed Index: Flame-spread index of 25 and a smoke-developed index of 50 when tested in accordance with ASTM E84.

J. Insulation Jacket, Field Applied - PVDC-SSL:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [Johns Manville; a Berkshire Hathaway company]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. <Insert manufacturer's name>
 3. Description: PVDC jacket with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
 4. Thickness: **6 mils (0.15 mm)**.
 5. Permeance: **0.01 perm (0.007 metric perm)** when tested in accordance with ASTM E96/E96M.
 6. Flame-Spread/Smoke-Developed Index: Flame-spread index of 25 and a smoke-developed index of 50 when tested in accordance with ASTM E84.

2.17 FIELD-APPLIED FABRIC REINFORCING MESH FOR INSULATION

A. Woven Glass-Fiber Mesh for Pipe Insulation, Field Applied:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. <Insert manufacturer's name>
3. Description: Woven glass-fiber mesh for covering pipe and pipe fittings insulation.
4. Weight: Approximately **2 oz./sq. yd. (68 g/sq. m)**.
5. Thread Count: **10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm)**.

B. Woven Polyester Mesh for Pipe Insulation, Field Applied:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Childers Brand; H. B. Fuller Construction Products]
 - b. [Foster Brand; H. B. Fuller]
 - c. [Vimasco Corporation]

- d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Childers Brand; H. B. Fuller Construction Products]**
 - b. **[Foster Brand; H. B. Fuller]**
 - c. **[Vimasco Corporation]**
 - d. **<Insert manufacturer's name>**
- 3. Description: Woven polyester mesh for covering pipe and pipe fittings insulation.
- 4. Weight: Approximately **1 oz./sq. yd. (34 g/sq. m)**.
- 5. Thread Count: **10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm)**.
- 6. Weave Type: Leno.

2.18 FIELD-APPLIED CLOTHS FOR INSULATION

A. Woven Glass-Fiber Cloth, Field Applied, for Insulation:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Alpha Associates, Inc.]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alpha Associates, Inc.]**
 - b. **<Insert manufacturer's name>**
- 3. Description: Woven glass-fiber cloth.
- 4. Standard: MIL-C-20079H, Type I.
- 5. Weave: Plain.
- 6. Weight: Minimum of **8 oz./sq. yd. (271 g/sq. m)**, presized.

2.19 VAPOR-RETARDER TAPES

A. Vapor-Retarder Tape for ASJ:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[3M Industrial Adhesives and Tapes Division]**
 - b. **[Aeroflex USA]**
 - c. **[Avery Dennison Corporation, Specialty Tapes Division]**
 - d. **[Ideal Tape Co., Inc., an American Biltrite Company]**
 - e. **[Knauf Insulation]**

f. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [3M Industrial Adhesives and Tapes Division]
- b. [Aeroflex USA]
- c. [Avery Dennison Corporation, Specialty Tapes Division]
- d. [Ideal Tape Co., Inc., an American Biltrite Company]
- e. [Knauf Insulation]
- f. <Insert manufacturer's name>

- 3. Description: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive.
- 4. Standard: ASTM C1136.
- 5. Width: [3 inches (75 mm)]<Insert value> .
- 6. Thickness: [11.5 mils (0.29 mm)]<Insert value> .
- 7. Adhesion: [90 ounces force/inch (1.0 N/mm)]<Insert value> in width.
- 8. Elongation: [2]<Insert number> percent.
- 9. Tensile Strength: [40 lbf/inch (7.2 N/mm)]<Insert value> in width.
- 10. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. Vapor-Retarder Tape for FSK:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [3M Industrial Adhesives and Tapes Division]
- b. [Avery Dennison Corporation, Specialty Tapes Division]
- c. [Ideal Tape Co., Inc., an American Biltrite Company]
- d. [Knauf Insulation]
- e. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [3M Industrial Adhesives and Tapes Division]
- b. [Avery Dennison Corporation, Specialty Tapes Division]
- c. [Ideal Tape Co., Inc., an American Biltrite Company]
- d. [Knauf Insulation]
- e. <Insert manufacturer's name>

- 3. Description: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive.
- 4. Standard: ASTM C1136.
- 5. Width: [3 inches (75 mm)]<Insert value> .
- 6. Thickness: [6.5 mils (0.16 mm)]<Insert value> .
- 7. Adhesion: [90 ounces force/inch (1.0 N/mm)]<Insert value> in width.
- 8. Elongation: [2]<Insert number> percent.
- 9. Tensile Strength: [40 lbf/inch (7.2 N/mm)]<Insert value> in width.
- 10. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Vapor-Retarder Tape for PVC:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [3M Industrial Adhesives and Tapes Division]
 - b. [Ideal Tape Co., Inc., an American Biltrite Company]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [3M Industrial Adhesives and Tapes Division]
 - b. [Ideal Tape Co., Inc., an American Biltrite Company]
 - c. <Insert manufacturer's name>
3. Description: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive.
4. Application: Suitable for indoor and outdoor applications.
5. Width: [2 inches (50 mm)]<Insert value> .
6. Thickness: [6 mils (0.15 mm)]<Insert value> .
7. Adhesion: [64 ounces force/inch (0.7 N/mm)]<Insert value> in width.
8. Elongation: [500]<Insert number> percent.
9. Tensile Strength: [18 lbf/inch (3.3 N/mm)]<Insert value> in width.

D. Vapor-Retarder Tape - Aluminum Foil:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [3M Industrial Adhesives and Tapes Division]
 - b. [Avery Dennison Corporation, Specialty Tapes Division]
 - c. [Ideal Tape Co., Inc., an American Biltrite Company]
 - d. [Knauf Insulation]
 - e. [Sekisui Voltek, LLC]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [3M Industrial Adhesives and Tapes Division]
 - b. [Avery Dennison Corporation, Specialty Tapes Division]
 - c. [Ideal Tape Co., Inc., an American Biltrite Company]
 - d. [Knauf Insulation]
 - e. [Sekisui Voltek, LLC]
 - f. <Insert manufacturer's name>
3. Description: Aluminum-foil vapor-retarder tape with acrylic adhesive.
4. Width: [2 inches (50 mm)]<Insert value> .
5. Thickness: [3.7 mils (0.093 mm)]<Insert value> .
6. Adhesion: [100 ounces force/inch (1.1 N/mm)]<Insert value> in width.
7. Elongation: [5]<Insert number> percent.
8. Tensile Strength: [34 lbf/inch (6.2 N/mm)]<Insert value> in width.

E. Vapor-Retarder Tape - PVDC, for Indoor Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
3. Description: White vapor-retarder PVDC tape with acrylic adhesive, for indoor applications.
4. Width: **[3 inches (75 mm)]<Insert value>** .
5. Film Thickness: **[2 mils (0.05 mm)]<Insert value>** .
6. Adhesive Thickness: **[1.5 mils (0.04 mm)]<Insert value>** .
7. Elongation at Break: **[120]<Insert number>** percent.
8. Tensile Strength: **[20 psi (138 kPa)]<Insert value>** in width.

F. Vapor-Retarder Tape - PVDC, for Outdoor Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johns Manville; a Berkshire Hathaway company]**
 - b. **<Insert manufacturer's name>**
3. Description: White vapor-retarder PVDC tape with acrylic adhesive for outdoor applications.
4. Width: **[3 inches (75 mm)]<Insert value>** .
5. Film Thickness: **[6 mils (0.15 mm)]<Insert value>** .
6. Adhesive Thickness: **[1.5 mils (0.04 mm)]<Insert value>** .
7. Elongation at Break: **[145]<Insert number>** percent.
8. Tensile Strength: **[55 psi (379 kPa)]<Insert value>** in width.

2.20 INSULATION SECUREMENTS

A. Insulation Bands:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [Johns Manville; a Berkshire Hathaway company]
 - b. [RPR Products, Inc.]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Johns Manville; a Berkshire Hathaway company]
 - b. [RPR Products, Inc.]
 - c. <Insert manufacturer's name>
 3. Insulation Bands - Stainless Steel: ASTM A240/A240M, [Type 304][or][Type 316] ; 0.015 inch (0.38 mm) thick, [1/2 inch (13 mm)][3/4 inch (19 mm)] wide with [wing seal][or][closed seal] .
 4. Insulation Bands - Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, [1/2 inch (13 mm)][3/4 inch (19 mm)] wide with [wing seal][or][closed seal] .
 5. Springs: Twin spring set constructed of stainless steel, with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.
- B. Insulation Staples: Outward-clinching insulation staples, nominal **3/4 inch (19 mm)** wide, stainless steel or Monel.
- C. Insulation Wire:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [C & F Wire Products]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [RPR Products, Inc.]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [C & F Wire Products]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [RPR Products, Inc.]
 - d. <Insert manufacturer's name>
 3. Description: [0.080-inch (2.0-mm) nickel-copper alloy][0.062-inch (1.6-mm) soft-annealed, stainless steel][0.062-inch (1.6-mm) soft-annealed, galvanized steel] .

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer **5 mils (0.127 mm)** thick and an epoxy finish **5 mils (0.127 mm)** thick if operating in a temperature range between **140 and 300 deg F (60 and 149 deg C)**. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 - 2. Carbon Steel: Coat carbon steel operating at a service temperature of between **32 and 300 deg F (0 and 149 deg C)** with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 INSTALLATION OF PIPING INSULATION, GENERAL

- A. Requirements in this article apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles below.
- B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- C. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.
- D. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- E. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.

- F. Install multiple layers of insulation with longitudinal and end seams staggered.
- G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- H. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents [, **unless otherwise approved by the Engineer-of-record**] .
- I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- J. Install insulation with least number of joints practical.
- K. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- L. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- M. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- N. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 - 2. Cover circumferential joints with **3-inch- (75-mm-)** wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced **4 inches (100 mm)** o.c.
 - 3. Overlap jacket longitudinal seams at least **1-1/2 inches (38 mm)**. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at [**2 inches (50 mm)**][**4 inches (100 mm)**] o.c.
 - 4. For below-ambient services, apply vapor-barrier mastic over staples.
 - 5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 - 6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- O. Cut insulation in a manner to avoid compressing insulation.
- P. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- Q. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least [**4 inches (100 mm)**]**<Insert value>** beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

- R. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
- S. Installation of Insulation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using **[prefabricated fitting insulation][or][mitered or routed fittings]** made from same material and density as that of adjacent pipe insulation. Each piece is butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with **[prefabricated fitting insulation][or][sectional pipe insulation]** of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using **[prefabricated fitting insulation][or][sectional pipe insulation]** of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using **[prefabricated fitting insulation][or][sectional pipe insulation]** of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "union". Match size and color of pipe labels.
- T. Insulate instrument connections for thermometers, pressure gauges, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- U. Install removable insulation covers **[at locations indicated on the Drawings]** . Installation conforms to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least **2 inches (50 mm)** over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least **2 inches (50 mm)** below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least **2 inches (50 mm)**.
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations That Are Not Fire Rated: Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 1. Comply with requirements in Section 078413 "Penetration Firestopping."
- F. Insulation Installation at Floor Penetrations:
 1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF CALCIUM-SILICATE PIPE INSULATION

A. On Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless steel bands at **12-inch (300-mm)** intervals, and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least **3 inches (75 mm)**. Secure inner layer with wire spaced at **12-inch (300-mm)** intervals. Secure outer layer with stainless steel bands at **12-inch (300-mm)** intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least **1 inch (25 mm)**. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. On Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
4. Finish flange insulation same as pipe insulation.

C. On Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When prefabricated insulation sections of insulation are not available, install mitered sections of calcium-silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

D. On Valves and Pipe Specialties:

1. Install pipe insulation, quads, hex sections, or beveled lag segments, adhered together, of calcium-silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.6 INSTALLATION OF CELLULAR-GLASS PIPE INSULATION

A. On Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient services, secure laps with outward-clinched staples at **6 inches (150 mm)** o.c.
4. For insulation with jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. On Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least **1 inch (25 mm)**, and seal joints with flashing sealant.

C. On Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered or routed sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. On Valves and Pipe Specialties:

1. Install prefabricated sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC PIPE INSULATION

A. On Equipment and Tanks:

1. Apply **[100]<Insert number>** percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

B. On Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. On Pipe Fittings and Elbows:

1. Install sections of pipe insulation and miter if required in accordance with manufacturer's written instructions.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. On Valves and Pipe Specialties:

1. Install prefabricated valve covers manufactured of same material as that of pipe insulation when

- available.
 - 2. When prefabricated valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Install insulation to flanges as specified for flange insulation application.
 - 4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- E. Finish: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

3.8 INSTALLATION OF GLASS-FIBER PIPE INSULATION

A. On Straight Pipes and Tubes:

- 1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
- 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
- 3. For insulation with jackets on above-ambient surfaces, secure laps with outward-clinched staples at **6 inches (150 mm) o.c.**
- 4. For insulation with jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. On Pipe Flanges:

- 1. Install prefabricated pipe insulation to outer diameter of pipe flange.
- 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
- 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber or mineral-wool blanket insulation.
- 4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least **1 inch (25 mm)**, and seal joints with flashing sealant.

C. On Pipe Fittings and Elbows:

- 1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
- 2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. On Valves and Pipe Specialties:

- 1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
- 2. When prefabricated sections are not available, install fabricated sections of pipe insulation to valve body.
- 3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
- 4. Install insulation to flanges as specified for flange insulation application.

3.9 INSTALLATION OF MINERAL WOOL PIPE INSULATION

A. On Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient surfaces, secure laps with outward-clinched staples at **6 inches (150 mm) o.c.**
4. For insulation with jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. On Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber or mineral-wool blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least **1 inch (25 mm)**, and seal joints with flashing sealant.

C. On Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. On Valves and Pipe Specialties:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated sections are not available, install fabricated sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.10 INSTALLATION OF PHENOLIC PIPE INSULATION

A. General Installation Requirements:

1. Secure single-layer insulation with stainless steel bands at **12-inch (300-mm)** intervals, and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least **3 inches (75 mm)**. Secure inner layer with **0.062-inch (1.6-mm)** wire spaced at **12-inch (300-mm)** intervals. Secure outer layer with stainless steel bands at **12-inch (300-mm)** intervals.

B. On Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming

- insulation materials.
- 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
- 3. For insulation with jackets on above-ambient services, secure laps with outward-clinched staples at **6 inches (150 mm)** o.c.
- 4. For insulation with jackets with vapor retarder on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

C. On Pipe Flanges:

- 1. Install prefabricated pipe insulation to outer diameter of pipe flange.
- 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
- 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.

D. On Pipe Fittings and Elbows:

- 1. Install prefabricated insulation sections, or mitered or routed fittings, of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. On Valves and Pipe Specialties:

- 1. Install prefabricated insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.
- 2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
- 3. Install insulation to flanges as specified for flange insulation application.

3.11 INSTALLATION OF POLYISOCYANURATE PIPE INSULATION

A. On Straight Pipes and Tubes:

- 1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
- 2. For insulation with jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic.
- 3. All insulation is tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. On Pipe Flanges:

- 1. Install preformed pipe insulation to outer diameter of pipe flange.
- 2. Make width of insulation section same as overall width of flange and bolts, and same thickness as that of adjacent pipe insulation, not to exceed **1-1/2-inch (38-mm)** thickness.
- 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.

C. On Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. On Valves and Pipe Specialties:

1. Install prefabricated sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.12 INSTALLATION OF POLYOLEFIN PIPE INSULATION

A. On Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive [**or via self-seal mechanism**] to eliminate openings in insulation that allow passage of air to surface being insulated.

B. On Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. On Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. On Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.13 INSTALLATION OF POLYSTYRENE PIPE INSULATION

A. On Straight Pipes and Tubes:

1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.

2. For insulation with jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic.
3. All insulation is tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. On Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, and make thickness same as that of adjacent pipe insulation, not to exceed **1-1/2 inches (38 mm)**.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness that of as pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.

C. On Pipe Fittings and Elbows:

1. Install prefabricated insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. On Valves and Pipe Specialties:

1. Install prefabricated section of polystyrene insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.14 INSTALLATION OF FIELD-APPLIED CLOTHS FOR INSULATION

A. Where woven glass-fiber cloths are indicated, install directly over bare insulation or insulation with factory-applied facings.

1. Draw cloths smooth and tight to surface with **2-inch (50-mm)** overlap at seams and joints.
2. Embed glass cloth between two **0.062-inch- (1.6-mm-)** thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

3.15 INSTALLATION OF FIELD-APPLIED INSULATION JACKETS

A. Insulation Jacket, Field Applied - FSK:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with **1-1/2-inch (38-mm)** laps at longitudinal seams and **3-inch- (75-mm-)** wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Insulation Jacket, Field Applied - PVC:

1. Install with **1-inch (25-mm)** overlap at longitudinal seams and end joints.

2. Seal with manufacturer's recommended adhesive.
 3. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- C. Insulation Jacket, Field Applied - Metal:
1. Install with **2-inch (50-mm)** overlap at longitudinal seams and end joints.
 2. Overlap longitudinal seams arranged to shed water.
 3. Seal end joints with weatherproof sealant recommended by insulation manufacturer.
 4. Secure jacket with stainless steel bands **12 inches (300 mm)** o.c. and at end joints.
- D. Insulation Jacket, Field-Applied - Outdoor, Self-Adhesive Asphaltic:
1. Install in accordance with manufacturer's written installation instructions.
- E. Insulation Jacket, Field-Applied - Indoor/Outdoor, Self-Adhesive (Non-Asphaltic):
1. Install in accordance with manufacturer's written installation instructions.
- F. Insulation Jacket, Field Applied - PVDC:
1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
 2. Wrap presized jackets around individual pipe insulation sections, with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of **2 inches (50 mm)** over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
 3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
 4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of **33-1/2 inches (850 mm)** or less. The **33-1/2-inch- (850-mm-)** circumference limit allows for **2-inch- (50-mm-)** overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
 5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.
- G. Insulation Jacket, Field Applied - PVDC-SSL:
1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
 2. Wrap presized jackets around individual pipe insulation sections, with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of **2 inches (50 mm)** over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
 3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
 4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of **33-1/2 inches (850 mm)** or less. The **33-1/2-inch- (850-mm-)** circumference limit allows for **2-inch- (50-mm-)** overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.

5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.16 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in [Section 099113 "Exterior Painting"] [Section 099114 "Exterior Painting (MPI Standards)"] and [Section 099123 "Interior Painting."] [Section 099124 "Interior Painting (MPI Standards)."]

1. Flat Acrylic Finish: [Two]<Insert number> finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

- a. Finish Coat Material: Interior, flat, latex-emulsion size.

- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless steel jackets.

3.17 FIELD QUALITY CONTROL

- A. Testing Agency: [Owner will engage][Engage] a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections [with the assistance of a factory-authorized service representative] .
- D. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to [three]<Insert number> locations of straight pipe, [three]<Insert number> locations of threaded fittings, [three]<Insert number> locations of welded fittings, [two]<Insert number> locations of threaded strainers, [two]<Insert number> locations of welded strainers, [three]<Insert number> locations of threaded valves, and [three]<Insert number> locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- E. All insulation applications will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.18 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 1. Underground piping.

2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.19 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water Piping below 60 Deg F (16 Deg C):

1. Insulation for All Pipe Sizes: To be one of the following:
 - a. Pipe Insulation - Cellular Glass, Preformed: [1-1/2 inches (38 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Flexible Elastomeric: [3/4 inch (19 mm)][1 inch (25 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: [1/2 inch (13 mm)][1 inch (25 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: [1/2 inch (13 mm)][1 inch (25 mm)]<Insert dimension> thick.
 - e. Pipe Insulation - Phenolic: [1 inch (25 mm)]<Insert dimension> thick.
 - f. Pipe Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
 - g. Pipe Insulation - Polyolefin: [3/4 inch (19 mm)][1 inch (25 mm)]<Insert dimension> thick.

B. Chilled Water and Brine Piping, 40 Deg F (5 Deg C) and below:

1. Insulation for Pipe Sizes NPS 3 (DN 80) and Smaller: To be one of the following:
 - a. Pipe Insulation - Cellular Glass, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Flexible Elastomeric: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - e. Pipe Insulation - Phenolic: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - f. Pipe Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
 - g. Pipe Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
2. Insulation for Pipe Sizes NPS 4 (DN 100) to NPS 12 (DN 300): To be one of the following:
 - a. Pipe Insulation - Cellular Glass, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Flexible Elastomeric: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - e. Pipe Insulation - Phenolic: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - f. Pipe Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
3. Insulation for Pipe Sizes NPS 14 (DN 350) and Larger: To be one of the following:
 - a. Pipe Insulation - Cellular Glass, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.

- b. Pipe Insulation - Glass-Fiber, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- c. Pipe Insulation - Glass-Fiber, Pipe and Tank: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- d. Pipe Insulation - Mineral Wool, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- e. Pipe Insulation - Mineral Wool, Pipe and Tank: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- f. Pipe Insulation - Phenolic: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.

C. Chilled Water and Brine Piping, Above 40 Deg F (5 Deg C):

1. Insulation for Pipe Sizes NPS 12 (DN 300) and Smaller: To be one of the following:

- a. Pipe Insulation - Cellular Glass, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
- b. Pipe Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
- c. Pipe Insulation - Glass-Fiber, Preformed: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
- d. Pipe Insulation - Mineral Wool, Preformed: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
- e. Pipe Insulation - Phenolic: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- f. Pipe Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
- g. Pipe Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.

2. Insulation for Pipe Sizes NPS 14 (DN 350) and Larger: To be one of the following:

- a. Pipe Insulation - Cellular Glass, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- b. Pipe Insulation - Glass-Fiber, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- c. Pipe Insulation - Glass-Fiber, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- d. Pipe Insulation - Mineral Wool, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- e. Pipe Insulation - Mineral Wool, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- f. Pipe Insulation - Phenolic: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.

D. Condenser-Water Supply and Return Piping:

1. Insulation for Pipe Sizes NPS 12 (DN 300) and Smaller: To be one of the following:

- a. Pipe Insulation - Cellular Glass, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
- b. Pipe Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
- c. Pipe Insulation - Glass-Fiber, Preformed: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
- d. Pipe Insulation - Mineral Wool, Preformed: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
- e. Pipe Insulation - Phenolic: [1 inch (25 mm)][1-1/2 inches (38 mm)]<Insert dimension> thick.

- f. Pipe Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
 - g. Pipe Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
2. Insulation for Pipe Sizes NPS 14 (DN 350) Larger: To be one of the following:
- a. Pipe Insulation - Cellular Glass, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Glass-Fiber, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - e. Pipe Insulation - Mineral Wool, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - f. Pipe Insulation - Phenolic: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- E. Heating-Hot-Water Supply and Return Piping, 200 Deg F (93 Deg C) and Below:
1. Insulation for Pipe Sizes NPS 12 (DN 300) and Smaller: To be one of the following:
- a. Pipe Insulation - Cellular Glass, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Glass-Fiber, Preformed: [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Mineral Wool, Preformed: [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Phenolic: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - e. Pipe Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
2. Insulation for Pipe Sizes NPS 14 (DN 350) and Larger: To be one of the following:
- a. Pipe Insulation - Cellular Glass, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Glass-Fiber, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - e. Pipe Insulation - Mineral Wool, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - f. Pipe Insulation - Phenolic: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- F. Heating-Hot-Water Supply and Return Piping, Above 200 Deg F (93 Deg C):
1. Insulation for Pipe Sizes NPS 3/4 (DN 20) and Smaller: To be one of the following:
- a. Pipe Insulation - Calcium Silicate, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Cellular Glass, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.

- d. mm)]<Insert dimension> thick.
Pipe Insulation - Mineral Wool, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
- 2. Insulation for Pipe Sizes NPS 1 (DN 25) and Larger: To be one of the following:
 - a. Pipe Insulation - Calcium Silicate, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Cellular Glass, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
- G. Steam and Steam Condensate Piping, Boiler Blowdown Piping, Steam and Steam Condensate Vent Piping, Drain Piping, and Safety Relief Vent Piping 350 Deg F (177 Deg C) and Below:
 - 1. Insulation for Pipe Sizes NPS 3/4 (DN 20) and Smaller: To be one of the following:
 - a. Pipe Insulation - Calcium Silicate, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Cellular Glass, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - 2. Insulation for Pipe Sizes NPS 1 (DN 25) and Larger: To be one of the following:
 - a. Pipe Insulation - Calcium Silicate, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Cellular Glass, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Glass-Fiber, Pipe and Tank: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - e. Pipe Insulation - Mineral Wool, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - f. Pipe Insulation - Mineral Wool, Pipe and Tank: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
- H. Steam and Steam Condensate Piping, Boiler Blowdown Piping, Steam and Steam Condensate Vent Piping, Steam and Steam Condensate Drain Piping, and Safety Relief Vent Piping Above 350 Deg F (177 Deg C):
 - 1. Insulation for Pipe Sizes NPS 3/4 (DN 20) and Smaller: To be one of the following:
 - a. Pipe Insulation - Calcium Silicate, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Cellular Glass, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: [1-1/2 inches (38 mm)][2 inches (50

- mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
 - 2. Insulation for Pipe Sizes NPS 1 (DN 25) and Larger: To be one of the following:
 - a. Pipe Insulation - Calcium Silicate, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Cellular Glass, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Glass-Fiber, Pipe and Tank: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - e. Pipe Insulation - Mineral Wool, Preformed: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
 - f. Pipe Insulation - Mineral Wool, Pipe and Tank: [3 inches (75 mm)][4 inches (100 mm)]<Insert dimension> thick.
- I. Refrigerant Suction and Hot-Gas Piping:
 - 1. Insulation for All Pipe Sizes: To be one of the following:
 - a. Pipe Insulation - Cellular Glass, Preformed: [1-1/2 inches (38 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: [1 inch (25 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: [1 inch (25 mm)]<Insert dimension> thick.
 - e. Pipe Insulation - Phenolic: [1 inch (25 mm)]<Insert dimension> thick.
 - f. Pipe Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
 - g. Pipe Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- J. Refrigerant Suction and Hot-Gas Flexible Tubing:
 - 1. Insulation for All Pipe Sizes: To be one of the following:
 - a. Pipe Insulation - Flexible Elastomeric: [2 inches (50 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Polyolefin: [2 inches (50 mm)]<Insert dimension> thick.
- K. Refrigerant Liquid Piping:
 - 1. Insulation for All Pipe Sizes: To be one of the following:
 - a. Pipe Insulation - Cellular Glass, Preformed: [1-1/2 inches (38 mm)]<Insert dimension> thick.
 - b. Pipe Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: [1 inch (25 mm)]<Insert dimension> thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: [1 inch (25 mm)]<Insert dimension> thick.
 - e. Pipe Insulation - Phenolic: [1 inch (25 mm)]<Insert dimension> thick.
 - f. Pipe Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
 - g. Pipe Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.
- L. Dual-Service Heating and Cooling Piping, 40 to 200 Deg F (5 to 93 Deg C):
 - 1. Insulation for NPS 12 (DN 300) and Smaller: To be one of the following:

- a. Pipe Insulation - Cellular Glass, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
- b. Pipe Insulation - Flexible Elastomeric: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
- c. Pipe Insulation - Glass-Fiber, Preformed: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
- d. Pipe Insulation - Mineral Wool, Preformed: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> thick.
- e. Pipe Insulation - Phenolic: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- f. Pipe Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.

2. Insulation for NPS 14 (DN 350) and Larger: To be one of the following:

- a. Pipe Insulation - Cellular Glass, Preformed: [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- b. Pipe Insulation - Mineral Wool, Preformed: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- c. Pipe Insulation - Mineral Wool, Pipe and Tank: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.
- d. Pipe Insulation - Phenolic: [1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> thick.

M. Heat-Recovery Piping:

1. Insulation for All Pipe Sizes: To be one of the following:

- a. Pipe Insulation - Cellular Glass, Preformed: [1-1/2 inches (38 mm)]<Insert dimension> thick.
- b. Pipe Insulation - Flexible Elastomeric: [1 inch (25 mm)]<Insert dimension> thick.
- c. Pipe Insulation - Glass-Fiber, Preformed: [1 inch (25 mm)]<Insert dimension> thick.
- d. Pipe Insulation - Glass-Fiber, Pipe and Tank: [1 inch (25 mm)]<Insert dimension> thick.
- e. Pipe Insulation - Mineral Wool, Preformed: [1 inch (25 mm)]<Insert dimension> thick.
- f. Pipe Insulation - Mineral Wool, Pipe and Tank: [1 inch (25 mm)]<Insert dimension> thick.
- g. Pipe Insulation - Phenolic: [1 inch (25 mm)]<Insert dimension> thick.
- h. Pipe Insulation - Polyisocyanurate: [1 inch (25 mm)]<Insert dimension> thick.
- i. Pipe Insulation - Polyolefin: [1 inch (25 mm)]<Insert dimension> thick.

3.20 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water and Brine Piping:

1. Insulation for All Pipe Sizes: To be one of the following:

- a. Pipe Insulation - Cellular Glass, Preformed: [3 inches (75 mm)]<Insert dimension> thick.
- b. Pipe Insulation - Flexible Elastomeric: [3 inches (75 mm)]<Insert dimension> thick.
- c. Pipe Insulation - Glass-Fiber, Preformed: [3 inches (75 mm)]<Insert dimension> thick.
- d. Pipe Insulation - Mineral Wool, Preformed: [3 inches (75 mm)]<Insert dimension> thick.
- e. Pipe Insulation - Phenolic: [2 inches (50 mm)]<Insert dimension> thick.
- f. Pipe Insulation - Polyisocyanurate: [2 inches (50 mm)]<Insert dimension> thick.
- g. Pipe Insulation - Polystyrene: [2 inches (50 mm)]<Insert dimension> thick.

B. Condenser-Water Supply and Return Piping:

1. Insulation for All Pipe Sizes: To be one of the following:
 - a. Pipe Insulation - Cellular Glass, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
 - b. Pipe Insulation - Flexible Elastomeric: **[2 inches (50 mm)]<Insert dimension>** thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
 - e. Pipe Insulation - Phenolic: **[2 inches (50 mm)]<Insert dimension>** thick.
 - f. Pipe Insulation - Polyisocyanurate: **[2 inches (50 mm)]<Insert dimension>** thick.
 - g. Pipe Insulation - Polystyrene: **[2 inches (50 mm)]<Insert dimension>** thick.
- C. Heating-Hot-Water Supply and Return Piping, 200 Deg F (93 Deg C) and Below:
 1. Insulation for All Pipe Sizes: To be one of the following:
 - a. Pipe Insulation - Cellular Glass, Preformed: **[3 inches (75 mm)]<Insert dimension>** thick.
 - b. Pipe Insulation - Glass-Fiber, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
 - c. Pipe Insulation - Mineral Wool, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
 - d. Pipe Insulation - Phenolic: **[2 inches (50 mm)]<Insert dimension>** thick.
 - e. Pipe Insulation - Polyisocyanurate: **[2 inches (50 mm)]<Insert dimension>** thick.
- D. Heating-Hot-Water Supply and Return Piping, Above 200 Deg F (93 Deg C):
 1. Insulation for All Pipe Sizes: To be one of the following:
 - a. Pipe Insulation - Calcium Silicate, Preformed: **[3 inches (75 mm)]<Insert dimension>** thick.
 - b. Pipe Insulation - Cellular Glass, Preformed: **[3 inches (75 mm)]<Insert dimension>** thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
- E. Steam and Steam Condensate Piping and Safety Relief Vent Piping, 350 Deg F (177 Deg C) and Below:
 1. Insulation for All Pipe Sizes: To be one of the following:
 - a. Pipe Insulation - Calcium Silicate, Preformed: **[4 inches (100 mm)]<Insert dimension>** thick.
 - b. Pipe Insulation - Cellular Glass, Preformed: **[4 inches (100 mm)]<Insert dimension>** thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: **[3 inches (75 mm)]<Insert dimension>** thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: **[3 inches (75 mm)]<Insert dimension>** thick.
- F. Steam and Steam Condensate Piping and Safety Relief Vent Piping Above 350 Deg F (177 Deg C):
 1. Insulation for All Pipe Sizes: To be one of the following:
 - a. Pipe Insulation - Calcium Silicate, Preformed: **[5 inches (125 mm)]<Insert dimension>** thick.
 - b. Pipe Insulation - Cellular Glass, Preformed: **[5 inches (125 mm)]<Insert dimension>** thick.
 - c. Pipe Insulation - Glass-Fiber, Preformed: **[4 inches (100 mm)]<Insert dimension>** thick.
 - d. Pipe Insulation - Mineral Wool, Preformed: **[4 inches (100 mm)]<Insert dimension>** thick.
- G. Refrigerant Suction and Hot-Gas Piping:
 1. Insulation for All Pipe Sizes: To be one of the following:



- a. Pipe Insulation - Cellular Glass, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
- b. Pipe Insulation - Flexible Elastomeric: **[2 inches (50 mm)]<Insert dimension>** thick.
- c. Pipe Insulation - Glass-Fiber, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
- d. Pipe Insulation - Mineral Wool, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
- e. Pipe Insulation - Phenolic: **[2 inches (50 mm)]<Insert dimension>** thick.
- f. Pipe Insulation - Polyisocyanurate: **[2 inches (50 mm)]<Insert dimension>** thick.
- g. Pipe Insulation - Polystyrene: **[2 inches (50 mm)]<Insert dimension>** thick.

H. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. Insulation for All Pipe Sizes: To be the following:

- a. Pipe Insulation - Flexible Elastomeric: **[2 inches (50 mm)]<Insert dimension>** thick.

I. Refrigerant Liquid Piping:

1. Insulation for All Pipe Sizes: To be one of the following:

- a. Pipe Insulation - Flexible Elastomeric: **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>** thick.
- b. Pipe Insulation - Polyolefin: **[1 inch (25 mm)]<Insert dimension>** thick.

J. Heat-Recovery Piping:

1. Insulation for All Pipe Sizes: To be one of the following:

- a. Pipe Insulation - Cellular Glass, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
- b. Pipe Insulation - Flexible Elastomeric: **[2 inches (50 mm)]<Insert dimension>** thick.
- c. Pipe Insulation - Glass-Fiber, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
- d. Pipe Insulation - Mineral Wool, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
- e. Pipe Insulation - Phenolic: **[2 inches (50 mm)]<Insert dimension>** thick.
- f. Pipe Insulation - Polyisocyanurate: **[2 inches (50 mm)]<Insert dimension>** thick.
- g. Pipe Insulation - Polystyrene: **[2 inches (50 mm)]<Insert dimension>** thick.

K. Dual-Service Heating and Cooling:

1. Insulation for All Pipe Sizes: To be one of the following:

- a. Pipe Insulation - Cellular Glass, Preformed: **[3 inches (75 mm)]<Insert dimension>** thick.
- b. Pipe Insulation - Glass-Fiber, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
- c. Pipe Insulation - Mineral Wool, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
- d. Pipe Insulation - Phenolic: **[2 inches (50 mm)]<Insert dimension>** thick.
- e. Pipe Insulation - Polyisocyanurate: **[2 inches (50 mm)]<Insert dimension>** thick.

L. Fuel Oil Piping, Heated:

1. Insulation for All Pipe Sizes: To be one of the following:

- a. Pipe Insulation - Cellular Glass, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
- b. Pipe Insulation - Glass-Fiber, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.
- c. Pipe Insulation - Mineral Wool, Preformed: **[2 inches (50 mm)]<Insert dimension>** thick.

3.21 OUTDOOR, UNDERGROUND, PIPING INSULATION SCHEDULE

- A. Insulation for belowground piping is specified in Section 232113.13 "Underground Hydronic Piping" and Section 232213.13 "Underground Steam and Condensate Heating Piping."
- B. Chilled Water Piping, All Sizes: Pipe insulation - cellular glass, preformed, **[2 inches (50 mm)]<Insert dimension>** thick.
- C. Condenser-Water Supply and Return Piping, All Sizes: Pipe insulation - cellular glass, preformed, **[2 inches (50 mm)]<Insert dimension>** thick.
- D. Heating-Hot-Water Supply and Return Piping, All Sizes, 200 Deg F (93 Deg C) and Below: Pipe insulation - cellular glass, preformed, **[3 inches (75 mm)]<Insert dimension>** thick.
- E. Heating-Hot-Water Supply and Return Piping, All Sizes, Above 200 Deg F (93 Deg C):
 - 1. Pipe Insulation - Calcium Silicate, Preformed: **[3 inches (75 mm)]<Insert dimension>** thick.
 - 2. Pipe Insulation - Cellular Glass, Preformed: **[3 inches (75 mm)]<Insert dimension>** thick.
- F. Steam and Steam Condensate Piping, All Sizes, 350 Deg F (177 Deg C) and Below:
 - 1. Pipe Insulation - Calcium Silicate, Preformed: **[4 inches (100 mm)]<Insert dimension>** thick.
 - 2. Pipe Insulation - Cellular Glass, Preformed: **[4 inches (100 mm)]<Insert dimension>** thick.
- G. Steam and Steam Condensate Piping, All Sizes, Above 350 Deg F (177 Deg F):
 - 1. Pipe Insulation - Calcium Silicate, Preformed: **[5 inches (125 mm)]<Insert dimension>** thick.
 - 2. Pipe Insulation - Cellular Glass, Preformed: **[5 inches (125 mm)]<Insert dimension>** thick.
- H. Dual-Service Heating and Cooling Piping, All Sizes, 40 to 200 Deg F (4 to 93 Deg C): Pipe insulation - cellular glass, preformed, **[3 inches (75 mm)]<Insert dimension>** thick.
- I. Fuel Oil Piping, All Sizes, Heated: Pipe insulation - cellular glass, preformed, **[2 inches (50 mm)]<Insert dimension>** thick.

3.22 INDOOR, FIELD-APPLIED INSULATION JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed from View:
 - 1. None.
 - 2. PVC: **[Standard][Color-coded by system]** .
 - a. Thickness: **[20 mils (0.5 mm)][30 mils (0.8 mm)]** .
 - 3. Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .

4. Painted Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)]** .
5. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth No. 2B finish][corrugated][stucco embossed]** .
 - a. Thickness: **[0.010 inch (0.25 mm)][0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .

D. Piping, Exposed to View:

1. None.
2. PVC: **[Standard][Color-coded by system]** .
 - a. Thickness: **[20 mils (0.5 mm)][30 mils (0.8 mm)]** .
3. Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
4. Painted Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)]** .
5. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth No. 2B finish][corrugated][stucco embossed]** .
 - a. Thickness: **[0.010 inch (0.25 mm)][0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .

3.23 OUTDOOR, FIELD-APPLIED INSULATION JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed from View:
 1. None.
 2. PVC: **[Standard][Color-coded by system]** .
 - a. Thickness: **[20 mils (0.5 mm)][30 mils (0.8 mm)]** .
 3. Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .

4. Painted Aluminum: **[Smooth][Corrugated][Stucco embossed]** .
 - a. Thickness: **[0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)]** .
 5. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth No. 2B finish][corrugated][stucco embossed]** .
 - a. Thickness: **[0.010 inch (0.25 mm)][0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .
- D. Piping, Exposed to View:
1. PVC: **[Standard][Color-coded by system]** .
 - a. Thickness: **[20 mils (0.5 mm)][30 mils (0.8 mm)][40 mils (1.0 mm)]** .
 2. Aluminum: **[Smooth][Stucco embossed]** with **[1-1/4-inch- (32-mm-) deep corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs]** .
 - a. Thickness: **[0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
 3. Painted Aluminum: **[Smooth][Stucco embossed]** with **[1-1/4-inch- (32-mm-) deep corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs]** .
 - a. Thickness: **[0.032 inch (0.81 mm)][0.040 inch (1.0 mm)]** .
 4. Stainless Steel: **[Type 304][or][Type 316]** , **[smooth][stucco embossed]** , with **[1-1/4-inch- (32-mm-) deep corrugations][2-1/2-inch- (65-mm-) deep corrugations][4-by-1-inch (100-by-25-mm) box ribs]** .
 - a. Thickness: **[0.020 inch (0.51 mm)][0.024 inch (0.61 mm)]** .
- 3.24 UNDERGROUND, FIELD-APPLIED INSULATION JACKET
- A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 23 07 19 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 07 19 00	22 05 76 00	Storm Drainage Piping Specialties



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 08 00 00 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes Cx process requirements for the following HVAC systems, assemblies, and equipment:
 - 1. Energy supply systems.
 - 2. Heat generation systems.
 - 3. Cooling generation systems.
 - 4. Central-station air-handling systems.
 - 5. Air, steam, and hydronic distribution systems.
 - 6. Heating and cooling terminal and unitary equipment.
 - 7. HVAC controls.
 - 8. TAB verification.
 - 9. **<Insert additional systems>.**
- B. Related Requirements:
 - 1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
 - 2. For construction checklists, comply with requirements in various Division 23 Sections specifying HVAC systems, system components, equipment, and products.

1.2 DEFINITIONS

- A. BAS: Building automation system.
- B. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."
- C. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."
- D. IgCC: International Green Construction Code.
- E. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they mean "as-built" systems, assemblies, subsystems, equipment, and components.
- F. TAB: Testing, adjusting, and balancing.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[BAS][and][HVAC]** testing technician.
- B. Construction Checklists:
 - 1. Draft Cx plan, including draft construction checklists to be prepared by CxA under Section 019113 "General Commissioning Requirements." Div. 23 Subcontractor is to review Construction Checklist in accordance with requirements in Section 019113 "General Commissioning

2. Requirements" and ASHRAE 202 and to resolve any issues with the CxA.
Cx plan, including material, installation, and performance construction checklists for systems, assemblies, subsystems, equipment, and components relating to **[BAS][and][HVAC]** to be part of the Cx process and in accordance with requirements in Section 019113 "General Commissioning Requirements and ASHRAE 202."

C. Test Equipment and Instruments: For all test equipment and instruments to be used in conducting Cx tests by Div. 23 Subcontractor, provide the following:

1. Equipment/instrument identification number.
2. Planned Cx application or use.
3. Manufacturer, make, model, and serial number.
4. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
5. Equipment manufacturers' proprietary instrumentation and tools. For each instrument or tool, identify the following:
 - a. Instrument or tool identification number.
 - b. Equipment schedule designation of equipment for which the instrument or tool is required.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

1.4 QUALITY ASSURANCE

A. BAS Testing Technician Qualifications: Technicians performing BAS Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations are to have the following minimum qualifications:

1. Journey level or equivalent skill level with knowledge of BAS, HVAC, electrical concepts, and building operations.
2. Minimum **[three years]<Insert time>** experience installing, servicing, and operating systems manufactured by approved manufacturer.
3. International Society of Automation (ISA)-Certified Control Systems Technician (CCST) Level I.

B. HVAC Testing Technician Qualifications: Technicians to perform HVAC Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:

1. Journey level or equivalent skill level; vocational school four-year-program graduate or an Associate's degree in mechanical systems, air conditioning, or similar field. Degree may be offset by three years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC equipment, assemblies, and systems.
2. Minimum **[three years]<Insert time>** experience that is to include installing, servicing, and operating systems manufactured by approved manufacturer.

C. Testing Equipment and Instrumentation Quality and Calibration:

1. Capable of testing and measuring performance within the specified acceptance criteria.
2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
3. Be maintained in good repair and operating condition throughout duration of use on Project.

4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.

D. Proprietary Test Instrumentation and Tools:

1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:
 - a. Be calibrated by manufacturer with current calibration tags permanently affixed.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
2. HVAC proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Cx PROCESS

- A. Perform Cx process in accordance with Section 019113 "General Commissioning Requirements" for **[BAS][and][HVAC]** and in accordance with the following:
 1. **[IgCC, which requires compliance with ASHRAE 202].**
 2. **[ASHRAE 202].**
 3. **[Commissioning standards acceptable to the authority having jurisdiction].**
 4. **<Insert standard>.**

3.2 CONSTRUCTION CHECKLISTS

- A. Preliminary detailed construction checklists are to be prepared under Section 019113 "General Commissioning Requirements" for each **[BAS][and][HVAC]** system, assembly, subsystem, equipment, and component required to be commissioned, as detailed in **[IgCC and ASHRAE 202]**. Contractor performs the following:
 1. Review **[BAS][and][HVAC]** preliminary construction checklists and provide written comments on checklist items where appropriate.
 2. Return preliminary Construction Checklist with review comments within **[10]<Insert number>** days of receipt.
 3. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."
 4. Use only construction checklists marked "Approved for Use, (date)" When performing tests. Mark construction checklists in the appropriate place as indicated Project events are completed, and provide pertinent details and other information.
- B. Prepare preliminary detailed construction checklists for each **[BAS][and][HVAC]** system, assembly, subsystem, equipment, and component required to be commissioned, as detailed in **[IgCC and ASHRAE 202][ASHRAE 202]**.
 1. Submit preliminary construction checklists to CxA and Designer for review.
 2. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."

3. Use only construction checklists, marked "Approved for Use, (date)" when performing tests. Mark construction checklists in the appropriate place, as indicated Project events are completed and provide pertinent details and other information.

C. Systems required to be commissioned under IgCC:

1. Heating, ventilating, air-conditioning, and refrigeration systems (mechanical and/or passive) and associated controls.
2. Air-curtain systems.
3. Water-pumping and -mixing systems over **5 hp (4 kW)** and purification systems.
4. Renewable energy systems and energy storage systems.
5. Energy and building management and demand-control systems.

D. Additional systems required to be commissioned:

1. Energy supply systems, including the following:
 - a. Fuel-oil supply.
 - b. Fuel gas supply.
 - c. Central-plant steam supply.
 - d. Central-plant hot-water supply.
 - e. Solar-energy supply.
 - f. Renewable energy systems.
 - g. Energy storage systems.
 - h. Demand-control systems.
 - i. **<Insert supply sources>**.
2. Heat generation systems, including the following:
 - a. Boilers.
 - b. Furnaces.
 - c. Fuel-fired unit heaters.
 - d. Auxiliary equipment.
 - e. **<Insert equipment>**.
3. Cooling generation systems, including the following:
 - a. Water chillers.
 - b. Cooling towers.
 - c. Direct-expansion refrigeration systems.
 - d. **<Insert systems>**.
4. Air-handling systems, including the following:
 - a. Supply, return, and exhaust air fans, motors, and drives.
 - b. Automatic and gravity dampers.
 - c. Heating and cooling devices.
 - d. Humidification and dehumidification devices.
 - e. Air filters.
 - f. Hangers and supports.
 - g. Interlock between air-handling system and fire/smoke alarm system.
 - h. **<Insert components>**.
5. Air duct systems, including the following:

- a. Duct systems.
 - b. Air-duct accessories, including volume dampers, fire and smoke dampers, turning vanes, sound attenuators, and flexible connectors.
 - c. Duct-mounted access doors and panels.
 - d. Hangers and supports.
 - e. **<Insert components>.**
6. Air curtain systems.
 - a. Supply air fans and motors.
 - b. Heating and cooling devices.
 - c. **<Insert components>.**
7. Steam and hydronic distribution systems, including the following:
 - a. Steam distribution piping systems.
 - b. Condensate piping systems, including condensate pumps and all accessories.
 - c. Hydronic piping systems and all accessories.
 - d. Pumps and all accessories.
 - e. Sleeves and sleeve seals.
 - f. Meters and gauges.
 - g. General-duty and specialty valves.
 - h. Hangers and supports
 - i. Heat tracing.
 - j. **<Insert systems>.**
8. Refrigerant piping, including the following:
 - a. Refrigerant piping, fittings, and specialties.
 - b. Refrigerant charge.
 - c. Sleeves and sleeve seals.
 - d. Meters and gauges.
 - e. General-duty and specialty valves.
 - f. Hangers and supports.
 - g. **<Insert components>.**
9. Smoke-control systems, including the following:
 - a. Exhaust and makeup fans, motors, and drives.
 - b. Exhaust and makeup air distribution systems.
 - c. Smoke dampers.
 - d. Smoke detectors.
 - e. Fire and smoke alarm system interface.
 - f. **<Insert system>.**
10. Heating and cooling terminal and unitary equipment, including the following:
 - a. Unit ventilators.
 - b. Unit heaters.
 - c. Fan-coil units.
 - d. Finned-tube radiation.
 - e. Electric heating.
 - f. Unitary heating and cooling equipment.
 - g. **<Insert units>.**
11. Vibration isolation systems.

12. Controls and instrumentation, including the following:
 - a. Energy monitoring and recording system.
 - b. Controllers and sensors.
 - c. Automatic control valves, dampers, and actuators.
 - d. Control interface with fans, pumps, dampers, and other equipment and systems.
 - e. Demand-control systems.
 - f. **<Insert systems>**.
13. TAB Verification:
 - a. Airflow.
 - b. Water flow.
 - c. Space pressurization.
14. Documentation:
 - a. Mechanical systems manuals.
 - b. Documentation of required commissioning.
15. Mechanical insulation, including the following:
 - a. Duct and plenum insulation.
 - b. HVAC piping insulation.
16. **<Insert additional systems>**.

3.3 Cx TESTING PREPARATION

- A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating in accordance with the Contract Documents and approved submittals.
- B. Certify that HVAC instrumentation and control systems have been completed and calibrated, point-to-point checkout has been successfully completed, and systems are operating in accordance with their design sequence of operation, Contract Documents, and approved submittals. Certify that all sensors are operating within specified accuracy and all systems are set to and maintaining set points as required by the design documents.
- C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.4 Cx TEST CONDITIONS

- A. Perform tests using design conditions, whenever possible.
 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA,

- and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
- 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
- 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- B. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.
- C. If seasonal testing is specified, complete appropriate initial performance tests and documentation, and schedule seasonal tests.

3.5 Cx TESTS COMMON TO HVAC SYSTEMS

- A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.
- B. Test systems, assemblies, subsystems, equipment, and components for operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response in accordance with acceptance criteria.
- C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.
- D. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance test requirements specified in Division 23 Sections specifying HVAC systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
 - 1. Cx Construction Checklist verification tests.
 - 2. Cx Construction Checklist verification test demonstrations.

3.6 CONSTRUCTION CHECKLIST EXAMPLES

- A. Vibration Isolation in HVAC Systems:
 - 1. Prerequisites: Acceptance of results of construction checklists for vibration[**and seismic**] control devices specified in [Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment"] [Section 230548.13 "Vibration Controls for HVAC Piping and Equipment"].
 - 2. Components to Be Tested:
 - a. Vibration isolation control devices in HVAC systems.
 - b. Support systems.
 - 3. Test Purpose: Evaluate effectiveness of vibration isolation control devices.
 - 4. Test Conditions, Constant Speed Equipment: Measure vibration of the facility structure at [three]<Insert number> locations designated by Owner's witness while the isolated equipment operates.
 - 5. Test Conditions, Variable Speed Equipment: Measure vibration of the facility structure at [three]<Insert number> locations designated by Owner's witness at the following operating conditions:
 - a. Maximum speed.

- b. Minimum speed.
- c. Critical speed.

6. Acceptance Criteria: Structure-borne vibration not to exceed specified performance.

B. Heat Tracing in HVAC Systems:

1. Prerequisites: Acceptance of results of construction checklists for heat tracing specified in HVAC systems. Comply with requirements listed in Section 230533 "Heat Tracing for HVAC Piping."
2. Equipment and Systems to Be Tested:
 - a. Self-regulating, parallel-resistance heating cables.
 - b. Heat tracing circuit controller.
3. Test Purpose:
 - a. Evaluate response to ambient temperature below freeze-protection set point.
 - b. Evaluate heating cable fault alarm.
4. Test Conditions:
 - a. Subject temperature sensor to temperature approximately [3 deg F (2 deg C)]<Insert value> above freeze-protection set point (initial set point [41 deg F (5 deg C)]<Insert value>). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is energized.
 - b. Subject temperature sensor to temperature approximately [3 deg F (2 deg C)]<Insert value> below freeze-protection set point (initial set point [41 deg F (5 deg C)]<Insert value>). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is de-energized.
 - c. Simulate an electrical fault on the heating cable.
5. Acceptance Criteria:
 - a. Freeze-protection circuit is energized at set-point temperature of minus 2 deg F (1 deg C).
 - b. Freeze-protection circuit is de-energized at set-point temperature of plus 2 deg F (1 deg C).
 - c. Heater trace circuit controller initiates an alarm of cable fault. Alarm is correctly reported at the alarm panel.

3.7 TAB VERIFICATION

- A. Prerequisites: Completion of "Examination" Article requirements and correction of deficiencies, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
- B. Completion of "Preparation" Article requirements for preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
- C. Scope: HVAC air systems and hydronic piping systems.
- D. Purpose: Differential flow relationships intended to maintain air and water pressurization differentials between the various areas of Project.

E. Conditions of the Test:

1. Cx Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
2. Systems operating in full heating mode[**with minimum outside-air volume**].
3. Systems operating in full cooling mode[**with minimum outside-air volume**].
4. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.

F. Acceptance Criteria:

1. Under all conditions, rechecked measurements comply with "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
2. Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than the tolerances allowed.
3. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.8 HEATING CONTROL SYSTEM Cx TESTS

A. Heating-Water Supply Temperature Control:

1. Prerequisites: Installation verification of the following:
 - a. Startup of [boiler]<Insert boiler designation>[steam to hot-water converter]<Insert converter designation><Insert prime heating-water equipment>.
 - b. Startup of heating-water pump(s) <Insert pump designation(s)>.
 - c. TAB of heating-water flow and pressure.
 - d. Input Device: Heating-water supply temperature; [thermostat][thermistor temperature sensor][resistance temperature sensor]<Insert device designation>.
 - e. Output Device: Control valve <Insert device designation>.
 - f. Display the following at the operator's workstation:
 - 1) Heating-water supply temperature.
 - 2) Heating-water supply temperature set point.
 - 3) Control-valve position.
2. Scope: Heating-water system.
3. Purpose: Control of heating-water supply temperature at input device <Insert device designation>.
4. Conditions of the Test:
 - a. Minimum heating-water flow.
 - b. Midrange Heating-Water Flow: [50 to 60]<Insert number(s)> percent of maximum.
 - c. Maximum heating-water flow.
5. Acceptance Criteria: Under all conditions, heating-water supply temperature is within plus or minus [2.0 deg F (1.1 deg C)]<Insert temperature> of set point.

B. Heating-Water Supply Temperature Reset:

1. Prerequisites: Installation verification of the following:
 - a. Startup of [boiler]<Insert boiler designation>[steam to hot-water converter]<Insert converter designation><Insert prime heating-water equipment>.

- b. Startup of heating-water pump(s) <Insert pump designation(s)>.
 - c. TAB of heating-water flow and pressure.
 - d. Input Device: Heating-water supply temperature; [thermostat][thermistor temperature sensor][resistance temperature sensor]<Insert device designation>.
 - e. Input Device: Outdoor-air temperature; [electric, outdoor-air-reset controller][outdoor-air sensor].
 - f. Output Device: Control valve <Insert device designation>.
 - g. Display the following at the operator's workstation:
 - 1) Outdoor-air temperature.
 - 2) Heating-water supply temperature.
 - 3) Heating-water supply temperature set point.
 - 4) Control-valve position.
2. Scope: Heating-water system.
 3. Purpose: Control of heating-water supply temperature at heating-water supply temperature input device <Insert device designation> in response to variable outdoor-air temperature input; [electric, outdoor-air-reset controller][outdoor-air sensor]<Insert device designation>.
 4. Conditions of the Test: Outdoor-air temperature input value may be overridden for this test.
 - a. Low Temperature: Outdoor-air temperature between [minus 30 and 0 deg F (minus 34 and minus 18 deg C)]<Insert temperature range>.
 - b. Midrange Temperature: Outdoor-air temperature between [30 and 45 deg F (minus 1 and plus 7 deg C)]<Insert temperature range>.
 - c. High Temperature: Outdoor-air temperature above [65 deg F (18 deg C)]<Insert temperature>.
 5. Acceptance Criteria: Heating-water supply temperature resets in straight-line relationship with outdoor-air temperature for the following reset schedule. Under all conditions, heating-water supply temperature is within [2.0 deg F (1.1 deg C)]<Insert temperature> of set point.
 - a. [195 deg F (90 deg C)]<Insert temperature> heating water when outdoor-air temperature is [minus 30 deg F (minus 34 deg C)]<Insert temperature>.
 - b. [130 deg F (54 deg C)]<Insert temperature> heating water when outdoor-air temperature is [65 deg F (18 deg C)]<Insert temperature>.
 - c. Under all conditions, heating-water supply temperature is within plus or minus [2.0 deg F (1.1 deg C)]<Insert temperature> of set point.
- C. Control Primary Circulating Pump(s):
1. Prerequisites: Installation verification of the following:
 - a. Startup of heating-water pump(s) <Insert pump designation(s)>.
 - b. Input Device: Outdoor-air temperature; [electric, outdoor-air-reset controller][outdoor-air sensor]<Insert device designation>.
 - c. Output Device: Heating-water pump; [starter][DDC system command to starter]<Insert device designation> relay.
 - d. Display the following at the operator's workstation:
 - 1) Outdoor-air temperature.
 - 2) Operating status of primary circulating pump(s).
 2. Scope: Heating-water pump(s) <Insert pump designation(s)> and associated controls.
 3. Purpose: On-off control of heating-water pump(s) in response to variable outdoor-air temperature input; [electric, outdoor-air-reset controller][outdoor-air sensor]<Insert device designation>.

4. Conditions of the Test:
 - a. High Temperature: Outdoor-air temperature above [65 deg F (18 deg C)]<Insert temperature>.
 - b. Low Temperature: Outdoor-air temperature below [65 deg F (18 deg C)]<Insert temperature>.
5. Acceptance Criteria:
 - a. High Temperature: Pump(s) are off when outside-air temperature is above [65 deg F (18 deg C)]<Insert temperature>.
 - b. Low Temperature: Pump(s) are on when outside-air temperature is below [65 deg F (18 deg C)]<Insert temperature>.

3.9 CHILLER SYSTEM Cx TESTS

A. Start-and-Stop Condenser-Water Pump(s):

1. Prerequisites: Installation verification of the following:
 - a. Startup of condenser-water pump(s) <Insert pump designation>.
 - b. Startup of cooling tower <Insert cooling tower designation>.
 - c. Input Device: Water pressure transducer <Insert device designation>.
 - d. Input Device: [Space thermostat][DDC system outdoor-air temperature]<Insert device designation>.
 - e. Input Device: [Time clock][DDC system time schedule]<Insert device designation>.
 - f. Output Device: Hard wired through motor starter; [DDC system binary output]<Insert device designation>.
 - g. Output Device: [Time clock][Binary output]<Insert device designation>.
 - h. Display the following at the operator's workstation:
 - 1) Low-level cooling-tower sump alarm.
 - 2) Outdoor-air temperature.
 - 3) Cooling (software) demand indication.
 - 4) Time and time schedule.
 - 5) Condenser-water pump(s) on-off status.
 - 6) Condenser-water pump(s) on-off indication.
 - 7) Condenser-water flow indication.
2. Scope:
 - a. Condenser-water system, including condenser-water pump(s), cooling towers, and associated controls.
3. Purpose:
 - a. Condenser-water pump(s) lockout.
 - b. Condenser-water pump(s) start.
 - c. Condenser-water pump(s) shutdown.
 - d. Low-level cooling-tower sump alarm.
 - e. Condenser-water pump(s) time-of-day schedule.
4. Conditions of the Test:
 - a. Verify Lockout: Start with condenser-water pump enable-input devices in the "disable"

state to prevent pump start. One by one, place the enable-input devices in the "enable" state, and then return each to the "disable" state before placing the next enable-input device to the "enable" state.

- b. Verify Start: Start with condenser-water pump enable-input devices in the "disable" state to prevent pump start. One by one, place the enable-input devices in the "enable" state.
- c. Verify Shutdown: Place all enable-input devices in the "enable" state to allow the pump(s) to start. One by one, place the enable-input devices in the "disable" state, and then return each to the "enable" state before placing the next enable-input device to the "disable" state.
- d. Verify Schedule: Compare condenser-water pump start-and-stop schedule times with Owner-approved time-of-day schedule.

5. Acceptance Criteria:

- a. Lockout: No single enable-input device starts the pump(s) when released to the "enable" state.
- b. Start: Condenser-water pump(s) start when, and only when, all enable-input devices are in the "enable" state.
- c. Shutdown: Each enable-input device stops the condenser-water pump(s) when placed in the "disable" state, regardless of the state of other enable-input devices.
- d. Schedule: Condenser-water pump start-and-stop schedule times agree with Owner-approved time-of-day schedule.

B. Start-and-Stop Chilled-Water Pump(s):

1. Prerequisites: Installation verification of the following:

- a. Startup of chilled-water pump(s) <Insert pump designation(s)>.
- b. Startup of condenser-water pump(s) <Insert pump designation(s)>.
- c. Startup of cooling tower <Insert cooling tower designation>.
- d. Input Device: Flow switch in condenser-water circuit <Insert device designation>.
- e. Output Device: [Starter][DDC system command to starter]<Insert device designation> relay.
- f. Display one of the following at the operator's workstation:
 - 1) Chilled-water flow indication.
 - 2) Condenser-water flow indication.
 - 3) Chilled-water pump(s) on-off status.
 - 4) Chilled-water pump(s) on-off indication.

2. Scope: Chilled-water system, including chilled-water pump(s), associated controls, and condenser-water system controls.

3. Purpose:

- a. Chilled-water pump(s) start.
- b. Chilled-water pump(s) shutdown.

4. Conditions of the Test:

- a. Verify Start: Start with chilled-water pump enable-input device in the "disable" state to prevent pump start. Place the enable-input device in the "enable" state.
- b. Verify Shutdown: Start with the enable-input device in the "enable" state to allow the pump(s) to run. Then place the enable-input device in the "disable" state.

5. Acceptance Criteria:

- a. Start: Chilled-water pump(s) start when, and only when, the enable-input device is in the "enable" state.
- b. Shutdown: The enable-input device stops the chilled-water pump(s) when placed in the "disable" state.

C. Start-and-Stop Cooling-Tower Fans(s):

- 1. Prerequisites: Installation verification of the following:
 - a. Input Device: Flow switch in condenser-water circuit <Insert device designation>.
 - b. Output Device: [**Starter**][**DDC system command to starter**]<Insert device designation> relay.
 - c. Display:
 - 1) Condenser-water flow indication.
 - 2) Cooling-tower fan(s) on-off indication.
- 2. Scope: Condenser-water system, including cooling tower, condenser-water pump(s), and associated controls.
- 3. Purpose:
 - a. Cooling-tower fan(s) start.
 - b. Cooling-tower fan(s) shutdown.
- 4. Conditions of the Test:
 - a. Verify Start: Start with cooling-tower fan enable-input device in the "disable" state to prevent fan(s) start. Place the enable-input device in the "enable" state.
 - b. Verify Shutdown: Start with the enable-input device in the "enable" state to allow the fan(s) to run. Then place the enable-input device in the "disable" state.
- 5. Acceptance Criteria:
 - a. Start: Chilled-water pump(s) start when, and only when, the enable-input device is in the "enable" state.
 - b. Shutdown: The enable-input device stops the chilled-water pump(s) when placed in the "disable" state.

D. Alternative Chiller(s):

- 1. Prerequisites: Installation verification of the following:
 - a. Input Device: [**Electric alternator**][**DDC system software**]<Insert device designation>.
 - b. Output Device: [**Chiller**][**DDC system command to chiller**]<Insert device designation> terminal strip.
 - c. Display:
 - 1) Chiller(s) on-off indication.
 - 2) Chiller failure alarm.
- 2. Scope:
 - a. Chilled-water system and associated controls.
 - b. Condenser-water system and associated controls.

3. Purpose:
 - a. Lead-lag rotation of chillers.
 - b. Replacement of failed chiller in rotation.
 - c. Adding and dropping chillers as follows: **<Insert sequence and parameters>**.
 - d. Replacement of failed chiller in add/drop sequence.
 - e. Chiller failure alarm initiation.
4. Conditions of the Test:
 - a. Lead-Lag Rotation - Chiller Start: Create a number of chilled-water system start-stop cycles equal to the number of chillers plus one.
 - b. Lead-Lag Rotation - Lead Chiller Fail: Disable the lead chiller while it is running.
 - c. Lead-Lag Rotation - Lag Chiller Fail: Disable a lag chiller while it is running.
 - d. Lead-Lag Rotation - Chiller Start Fail: Disable a chiller while it is in standby mode. Initiate a lead-lag rotation call for the disabled chiller to start.
 - e. Add/Drop Sequence - Increasing Demand: Increase chilled-water demand incrementally to observe the corresponding addition of chillers. Increase demand gradually as the load approaches the set point for adding the next chiller, to permit observation of the actual load at the time the next chiller is enabled.
 - f. Add/Drop Sequence - Decreasing Demand: Decrease chilled-water demand incrementally to observe the corresponding dropping of chillers. Decrease demand gradually as the load approaches the set point for dropping the next chiller, to permit observation of the actual load at the time the next chiller is disabled.
5. Acceptance Criteria:
 - a. Lead-Lag Rotation - Chiller Start: On each chilled-water system start event, the **[other][next]** chiller in rotation starts as the lead chiller, and the previous lead chiller, is designated as the **[last-]lag** chiller.
 - b. Lead-Lag Rotation - Lead Chiller Fail: When the lead chiller fails, the **[other][next]** chiller in rotation starts as the lead chiller, and a chiller failure alarm, is initiated for the failed chiller.
 - c. Lead-Lag Rotation - Lag Chiller Fail: When the lag chiller fails, **[the next chiller in rotation starts as the lead chiller, and]** a chiller failure alarm is initiated for the failed chiller.
 - d. Lead-Lag Rotation - Chiller Start Fail: When a chiller fails to start, **[the next chiller in rotation starts in its place, and]** a chiller failure alarm is initiated for the failed chiller.
 - e. Add/Drop Sequence - Increasing Demand: Chillers are added at the specified load set point, plus or minus **[5]<Insert number>** percent. Chilled-water supply temperature remains stable within plus or minus **[2.0 deg F (1.1 deg C)]<Insert temperature>** of set point.
 - f. Add/Drop Sequence - Decreasing Demand: Chillers are dropped at the specified load set point, plus or minus **[5]<Insert number>** percent. Chilled-water supply temperature remains stable within plus or minus **[2.0 deg F (1.1 deg C)]<Insert temperature>** of set point.
 - g. Add/Drop Sequence - Operating Chiller Fail: When an operating chiller fails, the next chiller in sequence starts and a chiller failure alarm is initiated for the failed chiller.
 - h. Add/Drop Sequence - Chiller Start Fail: When a chiller fails to start, the next chiller in sequence starts in its place and a chiller failure alarm is initiated for the failed chiller.

3.10 TERMINAL UNIT EQUIPMENT Cx TESTS

A. VAV Terminal Air Units with Coils:

1. Prerequisites: Installation verification of the following:

- a. Occupancy Input Device: Occupancy sensor.
 - b. Occupancy Output Device: DDC system binary output.
 - c. Room Temperature Input Device: **[Room thermostat][Electronic temperature sensor]**.
 - d. Room Temperature Output Device: **[Pneumatic][Electronic]** damper actuators and control-valve operators.
 - e. Display the following at the operator's workstation:
 - 1) Room/area served.
 - 2) Room occupied/unoccupied.
 - 3) Room temperature indication.
 - 4) Room temperature set point.
 - 5) Room temperature set point, occupied.
 - 6) Room temperature set point, unoccupied.
 - 7) Air-damper position as percentage open.
 - 8) Control-valve position as percentage open.
2. Scope: VAV terminal air units with **[hydronic][steam]** coils in supply-air systems, and associated controls.
3. Purpose:
- a. Occupancy-dependent room temperature set-point reset.
 - b. Room temperature control.
4. Conditions of the Test:
- a. Cx Test Demonstration Sampling Rate: **[10]<Insert number>** percent of each model/size unit.
 - b. Temperature Control - Occupied: Start with the room unoccupied. Occupy the room and observe the change to occupied status. Observe temperature control until room temperature is stable at occupied set point, plus or minus **[1.0 deg F (0.6 deg C)]<Insert temperature>**.
 - c. Temperature Control - Unoccupied: Start with the room occupied. Vacate the room and observe the change to unoccupied status. Observe temperature control until room temperature is stable at unoccupied set point, plus or minus **[1.0 deg F (0.6 deg C)]<Insert temperature>**.
5. Acceptance Criteria:
- a. Temperature Control - Occupied:
 - 1) Control system status changes from "occupied" to "unoccupied" after the specified time.
 - 2) Room temperature is stable at occupied set point, plus or minus **[1.0 deg F (0.6 deg C)]<Insert temperature>** within **[10]<Insert number>** minutes of occupancy. Room temperature does not overshoot or undershoot set point by more than **[2.0 deg F (1.1 deg C)]<Insert temperature>** during transition.
 - b. Temperature Control - Unoccupied:
 - 1) Control system status changes from "unoccupied" to "occupied" **[immediately][after five minutes of continuous occupancy]**.
 - 2) Room temperature is stable at unoccupied set point, plus or minus **[1.0 deg F (0.6 deg C)]<Insert temperature>** within **[30]<Insert number>** minutes of occupancy.

3.11 AIR-HANDLING SYSTEM Cx TESTS

A. Supply Fan(s) Variable-Volume Control:

1. Prerequisites: Installation verification of the following:
 - a. Volume-Control Input Device: **[Static-pressure transmitter][Differential-pressure switch]** sensing supply-duct static pressure referenced to conditioned-space static pressure.
 - b. Volume-Control Output Device: **[Receiver controller][DDC system analog output][DDC system analog output to digital-to-pneumatic transducer]** to modulating damper actuator. Set inlet guide vanes to **[minimum][closed]** position when fan is stopped.
 - c. Volume-Control Input Device: **[Static-pressure transmitter][Differential-pressure switch]** sensing supply-duct static pressure referenced to conditioned-space static pressure.
 - d. Volume-Control Output Device: **[Receiver controller][DDC system analog output]** to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
 - e. High-Pressure Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
 - f. High-Pressure Output Device: **[Receiver controller][DDC system binary output]** to **[alarm panel][motor starter]**.
 - g. Display the following at the operator's workstation:
 - 1) Supply-fan-discharge static-pressure indication.
 - 2) Supply-fan-discharge static-pressure set point.
 - 3) Supply-fan airflow rate.
 - 4) Supply-fan **[inlet vane position][speed]**.
2. Scope: VAV supply fan units and associated controls.
3. Purpose:
 - a. Supply-air discharge static pressure control.
 - b. Response to excess supply-air discharge static pressure condition.
4. Conditions of the Test:
 - a. Minimum supply-air flow.
 - b. Midrange Supply-Air Flow: **[50 to 60]<Insert number(s)>** percent of maximum.
 - c. Maximum supply-air flow.
 - d. Excess supply-air discharge static pressure.
5. Acceptance Criteria:
 - a. At all supply-air flow rates, and during changes in supply-air flow, discharge air static pressure is at set point plus or minus **[2]<Insert number>** percent.
 - b. Fan stops and an alarm is initiated at the operator's workstation when supply-air discharge static pressure is at the excess static pressure, plus or minus **[2]<Insert number>** percent.

B. Air-Handler Mixed-Air Control:

1. Prerequisites: Installation verification of the following:
 - a. Minimum Position Input Device: **[Time clock][DDC system time schedule]** .
 - b. Output Device: **[Receiver controller][DDC system analog output][DDC system analog output to digital-to-pneumatic transducer]** to modulating damper actuator(s).

- c. Heating Reset Input Device: **[Room thermostat][DDC system software]** .
 - d. **[Supply][Mixed]**-Air Temperature Input Device: **[Duct-mounted thermostat][Electronic temperature sensor]**.
 - e. Cooling Reset Input Device: Outdoor- and return-air, duct-mounted **[thermostats][electronic temperature sensors]**.
 - f. Display the following at the operator's workstation:
 - 1) Mixed-air-temperature indication.
 - 2) Mixed-air-temperature set point.
 - 3) Mixed-air damper position.
2. Scope: Air handler with mixed-air control and associated controls.
 3. Purpose:
 - a. Occupied time control.
 - b. Minimum damper position control.
 - c. Heating reset control.
 - d. **[Supply][Mixed]**-air temperature control.
 - e. Cooling reset control.
 - f. Unoccupied time control.
 4. Conditions of the Test:
 - a. Occupied Time Control: Start in unoccupied schedule. Advance to occupied schedule time.
 - b. Minimum Damper Position Control: Command system to mode in which minimum damper position is required.
 - c. Heating Reset Control: Create a call for heating.
 - d. **[Supply][Mixed]**-Air Temperature Control: Override **[supply][mixed]**-air temperature set point to a value **[2.0 deg F (1.1 deg C)]<Insert temperature>** above current **[supply][mixed]**-air temperature.
 - e. Cooling Reset Control: Override outdoor-air **[temperature to a value that exceeds return-air temperature][enthalpy to a value that exceeds return-air enthalpy]**.
 - f. Unoccupied Time Control: Advance to unoccupied schedule time.
 - g. Control Data Trend Log: Set up a data trend log of the following input device values and output device commands. Record data at **[hourly]<Insert alternative recording frequency>** intervals. Submit trend data for **[24-hour]<Insert time>** periods in which natural conditions require heating reset control, **[supply][mixed]**-air temperature control, and cooling reset control.
 - 1) Minimum position input device.
 - 2) Heating reset input device.
 - 3) **[Supply][Mixed]**-air temperature input device.
 - 4) Cooling reset input device.
 5. Acceptance Criteria:
 - a. Occupied Time Control: Mixed-air control is active in occupied mode.
 - b. Minimum Damper Position Control: Controller **[opens minimum outdoor-air dampers][positions outdoor-air dampers to minimum position]**.
 - c. Heating Reset Control: Controller **[closes minimum outdoor-air dampers][sets outdoor-air dampers to minimum position]**.
 - d. **[Supply][Mixed]**-Air Temperature Control: Controller modulates outdoor-, return-, and relief-air dampers to maintain temporary **[supply][mixed]**-air temperature set point, plus or minus **[1.0 deg F (0.6 deg C)]<Insert temperature>**.
 - e. Cooling Reset Control: Controller sets outdoor-air dampers to minimum position when outdoor-air **[temperature exceeds return-air temperature][enthalpy exceeds return-air**



-
- f. **enthalpy].** Unoccupied Time Control: Controller positions outdoor- and relief-air dampers closed and return-air dampers open.
 - g. Control Data Trend Log: Data verify control in accordance with sequence of control.

END OF SECTION 23 08 00 00

SECTION 23 09 00 00 - SPEED INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Speed switches.
2. Combination speed switches and transmitters.
3. Speed sensors and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Operating characteristics, electrical characteristics, and furnished accessories indicating operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Product description with complete technical data and product specification sheets.
3. Installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and[**mounting**] details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades:

1. Product installation location shown in relationship to room, conduit, duct, pipe, and equipment.
2. Sizes and locations of wall access panels for instruments installed behind walls.
3. Sizes and locations of ceiling access panels for instruments installed in inaccessible ceilings.

B. Product Certificates: For each product requiring a certificate.

- C. Product Test Reports: For each speed instrument, for tests performed by **[manufacturer and witnessed by a qualified testing agency]****[a qualified testing agency]**.
- D. Source quality-control reports.
- E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: To include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 SPEED SWITCHES

- A. Rotational Speed Switches, Noncontact Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following]****[provide products by one of the following]****[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Electro Sensors]**
 - b. **[Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Rockwell Automation, Inc.]**
 - d. **[Torq Corporation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Electro Sensors]**
 - b. **[Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Rockwell Automation, Inc.]**
 - d. **[Torq Corporation]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all noncontact-type, rotational speed switches from a single manufacturer.
4. Description:
 - a. Speed switch, sensor, and electronics housed in enclosure and used to measure shaft rotational speed without direct contact to motor or equipment shaft.
 - b. Shaft-end-mounted disc or split collar wrap around shaft generates an alternating magnetic field sensed by the switch. Alternative technologies that use light in lieu of magnetic fields are acceptable contingent upon compliance with requirements indicated.
 - c. Rotation: Nondirectional, clockwise or counterclockwise.

5. Hazardous Environment Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Group D; Class II, Groups E, F, and G; and Class III.
6. Performance:
 - a. Field-Adjustable Speed Range: **[0.1 to 100][0.5 to 5000][6 to 150][15 to 80][50 to 1000][100 to 5000][150 to 3600]<Insert speed range>** rpm.
 - b. Set-Point Accuracy: **[0.5][1.5][3][5]<Insert value>** percent.
 - c. Temperature Limits: **[Minus 40 to 140 deg F (Minus 40 to 60 deg C)][Minus 22 to 140 deg F (Minus 30 to 60 deg C)][0 to 120 deg F (Minus 18 to 49 deg C)]<Insert temperature range>**.
 - d. Electrical Rating: **[1.8][5][10]<Insert value>** A at 115 or 240 V ac.
7. Switch Type: **[SPDT][or][DPDT]**.
8. Operator Interface: Potentiometer; screw or pushbutton adjustment.
9. Enclosure:
 - a. Material: **[Cast aluminum][Plastic]<Insert material>**.
 - b. Removable cover.
 - c. Rating: NEMA 250, **[Type 4][or][Type 4X]**.
 - d. Electrical Connection: Screw terminals.
 - e. Conduit Connection: **3/4-inch (21-mm) or 1-inch (27-mm)** trade size.
10. Disc, Guard, and Mounting Bracket Construction:
 - a. Magnetic Disc: **[Nylon][or][PVC]<Insert material>**.
 - b. Disc Guard: **[Aluminum][or][stainless steel]<Insert material>**.
 - c. Magnetic Split Collar Wrap: **[Aluminum][PVC][or][stainless steel]<Insert material>**.
 - d. Mounting Bracket: **[Aluminum][or][stainless steel]<Insert material>**.

B. Rotational Speed Switches, Contact Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Rockwell Automation, Inc.]**
 - c. **[Torq Corporation]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Rockwell Automation, Inc.]**
 - c. **[Torq Corporation]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all contact-type rotational speed switches from a single manufacturer.
4. Description:

- a. Speed switch, sensor, and electronics housed in one enclosure and used to measure shaft rotational speed with direct contact to motor or equipment shaft.
 - b. Rotation: Nondirectional, clockwise or counterclockwise.
5. Hazardous Environment Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Groups C and D; and Class II, Groups F and G.
6. Performance:
 - a. Field-Adjustable Ascending Speed Ranges: **[0.6 to 300][1 to 90][10 to 3700][15 to 80][50 to 1000][80 to 2550][600 to 3000]<Insert speed range>** rpm.
 - b. Descending Speed Range Set Point: **[15][20]<Insert value>** percent lower than ascending speed.
 - c. Repeatability: Within **[2][5][7]<Insert value>** percent of maximum speed in range.
 - d. Temperature Limits: **[Minus 60 to 250 deg F (Minus 51 to 121 deg C)][Minus 40 to 140 deg F (Minus 40 to 60 deg C)][Minus 22 to 140 deg F (Minus 30 to 60 deg C)][0 to 120 deg F (Minus 18 to 49 deg C)]<Insert temperature range>**.
 - e. Electrical Rating: **[3][5][10]<Insert value>** A at 120 or 240 V ac.
7. Switch Type: **[SPDT][or][DPDT]**.
8. Operator Interface: Adjustment screw.
9. Enclosure:
 - a. Material: **[Cast aluminum][Cast iron][or][FRP]<Insert material>**.
 - b. Removable screw-on cover.
 - c. Rating: NEMA 250, **[Type 1][Type 3R][Type 4][or][Type 4X]**.
 - d. Electrical Connection: Screw terminals.
 - e. Conduit Connection: **3/4-inch (21-mm)** trade size.

2.2 COMBINATION SPEED SWITCHES AND TRANSMITTERS

A. Combination Rotational Speed Switches and Transmitters, Noncontact Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Electro Sensors]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Electro Sensors]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all noncontact-type combination rotational speed switches and transmitters from a single manufacturer.
4. Description:
 - a. Speed switch, sensor, transmitter, and electronics housed in enclosure and used to

- measure shaft rotational speed without direct contact to motor or equipment shaft.
 - b. Shaft-end-mounted disc or split collar wrap around shaft generates an alternating magnetic field sensed by the combination switch and transmitter.
 - c. Rotation: Nondirectional, clockwise or counterclockwise.
- 5. Hazardous Environment Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Group D; Class II, Groups E, F, and G; and Class III.
- 6. Performance:
 - a. Field-Adjustable Speed Range: **[0.1 to 9999]<Insert speed range>** rpm.
 - b. Speed Accuracy: Within **[0.7]<Insert value>** percent of actual speed.
 - c. Temperature Limits: **[Minus 40 to 140 deg F (Minus 40 to 60 deg C)]<Insert temperature range>**.
 - d. Electrical Rating: **[5]<Insert value>** A at 250-V ac.
- 7. Analog Output Signal: 4 to 20 mA signal with programmable speed range endpoints; 4 mA for minimum speed and 20 mA for maximum speed.
- 8. Switch Type: SPDT; programmable for either failsafe over-speed alarm or failsafe under-speed alarm.
- 9. Digital Display: LCD; four digits indicating either rotational speed (rpm) or analog output signal (mA); alarm relay LED.
- 10. Operator Interface: Pushbutton adjustment.
- 11. Enclosure:
 - a. Material: Cast aluminum.
 - b. Removable cover.
 - c. Rating: NEMA 250, Type 4X.
 - d. Electrical Connection: Screw terminals.
 - e. Conduit Connection: **3/4-inch (21-mm)** trade size.
- 12. Disc, Guard, and Mounting Bracket Construction:
 - a. Magnetic Disc: Nylon.
 - b. Disc Guard: Aluminum or stainless steel.
 - c. Magnetic Split Collar Wrap: Aluminum, PVC, or stainless steel.
 - d. Mounting Bracket: Aluminum or stainless steel.

2.3 SPEED SENSORS AND TRANSMITTERS

A. Rotational Speed Sensors and Transmitters, Noncontact Type:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Electro Sensors]**
 - b. **[Process Control Systems]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Electro Sensors]**
 - b. **[Process Control Systems]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all noncontact-type rotational speed sensors and transmitters from a single manufacturer.
4. Description:
 - a. Speed sensor, transmitter, and electronics housed in enclosure and used to measure shaft rotational speed without direct contact to motor or equipment shaft.
 - b. Shaft-end-mounted disc or split collar wrap around shaft generates an alternating magnetic field sensed by the switch. Alternative technologies that use light in lieu of magnetic fields are acceptable contingent upon compliance with requirements indicated.
 - c. Rotation: Nondirectional, clockwise or counterclockwise.
5. Hazardous Environment Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Group D; Class II, Groups E, F, and G; and Class III.
6. Performance:
 - a. Field-Adjustable Speed Range: **[0.2 to 200][0.2 to 2000][5 to 10000]<Insert speed range>** rpm.
 - b. Speed Accuracy: **[0.5][2]<Insert value>** percent.
 - c. Temperature Limits: **[Minus 40 to 140 deg F (Minus 40 to 60 deg C)][Minus 4 to 176 deg F (Minus 20 to 80 deg C)]<Insert temperature range>**.
7. Analog Output Signal: 4 to 20 mA[**or 0 to 10 V dc**].
8. Sensor Cable: Two-wire, shielded cable, minimum 22 gauge copper.
9. Enclosure:
 - a. Material: Aluminum, stainless steel **[FRP][or][PVC]**.
 - b. Removable cover.
 - c. Rating: NEMA 250, **[Type 4][or][Type 4X]**.
 - d. Electrical Connection: Screw terminals.
 - e. Conduit Connection: **3/4-inch (21-mm)** trade size.
10. Disc, Guard, and Mounting Bracket Construction:
 - a. Magnetic Disc: **[Nylon]<Insert material>**.
 - b. Disc Guard: **[Aluminum][or][stainless steel]<Insert material>**.
 - c. Magnetic Split Collar Wrap: **[Aluminum][PVC][or][stainless steel]<Insert material>**.
 - d. Mounting Bracket: **[Aluminum][or][stainless steel]<Insert material>**.

2.4 SOURCE QUALITY CONTROL

- A. Factory Tests and Inspections: Test and inspect assembled speed instruments, as indicated by instrument requirements. Affix standards organization's certification and label.
- B. Prepare test and inspection reports as applicable.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SPEED INSTRUMENT APPLICATIONS

- A. Speed-Switch Applications:
 - 1. Rotational Speed Switches, Noncontact Type: **<Insert application>**.
 - 2. Rotational Speed Switches, Contact Type: **<Insert application>**.
- B. Combination Speed Switch and Transmitter Applications:
 - 1. Combination Rotational Speed Switches and Transmitters, Noncontact Type: **<Insert application>**.
- C. Speed Sensor and Transmitter Applications:
 - 1. Rotational Speed Sensors and Transmitters, Noncontact Type: **<Insert application>**.

3.3 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support speed-switch wiring and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.
- C. Fastening Hardware:
 - 1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- E. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they are subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments.
 - 3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable



for environment.

4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of **[Type 316L stainless steel]<Insert material>**.

3.4 INSTALLATION OF SPEED SWITCHES

- A. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.5 ELECTRICAL CONNECTIONS

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."

3.7 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification[**and on face of ceiling directly below instruments concealed above ceilings**].

3.8 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.9 CHECKOUT PROCEDURES

- A. Check installed products before continuity tests and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation with respect to location, elevation, orientation, or other applicable considerations that impact performance.
- D. Verify that wiring is correct and secure.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. Equipment and procedures used for calibration are to comply with instrument manufacturer's written instructions.
 - 4. Provide diagnostic and test equipment for calibration and adjustment.
 - 5. Field instruments and equipment used to test and calibrate installed instruments are to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent is to be checked by an instrument with an accuracy of 0.5 percent.
 - 6. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
 - 7. If, after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
 - 8. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11 in the absence of specific requirements and to supplement requirements indicated.
- B. Analog Signals:
 - 1. Check analog voltage signals using a voltage meter at zero, 50, and 100 percent of range.
 - 2. Check analog current signals using a current meter at zero, 50, and 100 percent or range.
- C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Switches: Calibrate switches to make or break contact at set points indicated.

3.11 ADJUSTING

- A. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.12 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes [three][six][nine][12] months' full maintenance by [skilled employees of systems and equipment Installer][manufacturer's authorized service representative]. Include [monthly][quarterly][semiannual][annual] preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

3.13 DEMONSTRATION

- A. [Engage a factory-authorized service representative to train][Train] Owner's maintenance personnel to adjust, operate, and maintain speed instruments.
- B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 09 00 00

SECTION 23 09 23 00 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Direct digital control (DDC) system for HVAC.
- B. Related Requirements:
 - 1. Section 230923.13 "Energy Meters" for thermal and electric power energy meters that connect to DDC systems.
 - 2. Section 230923.17 "Level Instruments" for liquid-level switches, sensors, and transmitters that connect to DDC systems.
 - 3. Section 230923.22 "Position Instruments" for limit switches that connect to DDC systems.
 - 4. Section 230923.33 "Vibration Instruments" for vibration instruments that connect to DDC systems.
 - 5. Section 230923.43 "Weather Stations" for weather stations that connect to DDC systems.
 - 6. Section 230993.11 "Sequence of Operations for HVAC DDC" for control sequences in DDC systems.
 - 7. Section 260553 "Identification for Electrical Systems" for identification requirements for electrical power and communications components

1.2 DEFINITIONS

- A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.
- B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
- C. BACnet Specific Definitions:
 - 1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data and services over a network.
 - 2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
 - 3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
 - 4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
- D. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.
- E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: network controllers, programmable application controllers, and application-specific controllers.



- F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.
- G. COV: Changes of value.
- H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.
- I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems to be capable of operating in a standalone mode using the last best available data.
- J. E/P: Voltage to pneumatic.
- K. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
- L. HLC: Heavy load conditions.
- M. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI) and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.
- N. I/P: Current to pneumatic.
- O. LAN: Local area network.
- P. LNS: LonWorks Network Services.
- Q. LON Specific Definitions:
 - 1. FTT-10: Echelon Transmitter-Free Topology Transceiver.
 - 2. LonMark International: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
 - 3. LonTalk: An open standard protocol developed by Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
 - 4. LonWorks: Network technology developed by Echelon.
 - 5. Node: Device that communicates using CTA-709.1-D protocol and that is connected to a CTA-709.1-D network.
 - 6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.
 - 7. Node ID: A unique 48-bit identifier assigned at factory to each CTA-709.1-D device. Sometimes called a "Neuron ID."
 - 8. Program ID: An identifier (number) stored in a device (usually, EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.
 - 9. Standard Configuration Property Type (SCPT): Pronounced "skip-it." A standard format type maintained by LonMark for configuration properties.
 - 10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type

- maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").
11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."
 12. TP/FT-10: Free Topology Twisted Pair network defined by CTA-709.3 and is most common media type for a CTA-709.1-D control network.
 13. TP/XF-1250: High-speed, 1.25 Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" and typically used only to connect multiple TP/FT-10 networks.
 14. User-Defined Configuration Property Type (UCPT): Pronounced "u-keep-it." A Configuration Property format type that is defined by device manufacturer.
 15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.
- R. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- S. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.
- T. Modbus TCP/IP: An open protocol for exchange of process data.
- U. MS/TP: Master-slave/token-passing, ISO/IEC/IEEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.
- V. MTBF: Mean time between failures.
- W. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.
- X. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.
- Y. Peer to Peer: Networking architecture that treats all network stations as equal partners.
- Z. POT: Portable operator's terminal.
- AA. RAM: Random access memory.
- BB. RF: Radio frequency.
- CC. Router: Device connecting two or more networks at network layer.
- DD. Server: Computer used to maintain system configuration, historical and programming database.
- EE. TCP/IP: Transport control protocol/Internet protocol.
- FF. UPS: Uninterruptible power supply.
- GG. USB: Universal Serial Bus.

HH. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

II. VAV: Variable air volume.

JJ. WLED: White light emitting diode.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.4 ACTION SUBMITTALS

A. Multiple Submissions:

1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

- a. Workstations.
- b. Printers.
- c. Servers.
- d. Gateways.
- e. Routers.
- f. Protocol analyzers.
- g. DDC controllers.
- h. Enclosures.
- i. Electrical power devices.
- j. UPS units.
- k. Accessories.
- l. Instruments.
- m. Control dampers and actuators.
- n. Control valves and actuators.
- o. **<Insert product>**.

6. When manufacturer's product datasheets apply to a product series rather than a specific product

- model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature to clearly cross reference specification and drawings that submittal is to cover.
- C. Software Submittal:
1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, **<Insert product,>** and DDC controller.
 2. Description and technical data of all software provided and cross-referenced to products in which software will be installed.
 3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
 4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
 5. Listing and description of each engineering equation used with reference source.
 6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
 7. Description of operator interface to alphanumeric and graphic programming.
 8. Description of each network communication protocol.
 9. Description of system database, including all data included in database, database capacity, and limitations to expand database.
 10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden, and system throughput.
 11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
- D. Shop Drawings:
1. General Requirements:
 - a. Include cover drawing with Project name, location, Owner, Architect, Contractor, and issue date with each Shop Drawings submission.
 - b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
 - c. Drawings Size: **<Insert requirements>**.
 2. Include plans, elevations, sections, and mounting details where applicable.
 3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 4. Detail means of vibration isolation and show attachments to rotating equipment.
 5. Plan Drawings indicating the following:
 - a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork, and piping.
 - b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
 - c. Each desktop workstation network port, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
 - d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
 - e. Network communication cable and raceway routing.
 - f. Information, drawn to scale, of **<Insert requirements>**.
 - g. Proposed routing of wiring, cabling, conduit, and tubing; coordinated with building services

for review before installation.

6. Schematic drawings for each controlled HVAC system indicating the following:
 - a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
 - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
 - c. A graphic showing location of control I/O in proper relationship to HVAC system.
 - d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
 - e. Unique identification of each I/O that to be consistently used between different drawings showing same point.
 - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
 - g. Narrative sequence of operation.
 - h. Graphic sequence of operation, showing all inputs and output logical blocks.
7. Control panel drawings indicating the following:
 - a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
 - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates, and allocated spare space.
 - c. Front, rear, and side elevations and nameplate legend.
 - d. Unique drawing for each panel.
8. DDC system network riser diagram indicating the following:
 - a. Each device connected to network with unique identification for each.
 - b. Interconnection of each different network in DDC system.
 - c. For each network, indicate communication protocol, speed, and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
 - d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
9. DDC system electrical power riser diagram indicating the following:
 - a. Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
 - b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
 - c. Each product requiring power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
 - d. Power wiring type and size, race type, and size for each.
10. Monitoring and control signal diagrams indicating the following:
 - a. Control signal cable and wiring between controllers and I/O.
 - b. Point-to-point schematic wiring diagrams for each product.
 - c. Control signal tubing to sensors, switches, and transmitters.
 - d. Process signal tubing to sensors, switches, and transmitters.

- e. Pneumatic main air and control signal tubing to pneumatic **[damper][and][valve]** actuators, pilot-positioners if applicable, and associated transducers.
- 11. Color graphics indicating the following:
 - a. Itemized list of color graphic displays to be provided.
 - b. For each display screen to be provided, a true color copy showing layout of pictures, graphics, and data displayed.
 - c. Intended operator access between related hierarchical display screens.
- E. System Description:
 - 1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
 - 2. Complete listing and description of each report, log and trend for format and timing, and events that initiate generation.
 - 3. System and product operation under each potential failure condition including, but not limited to, the following:
 - a. Loss of power.
 - b. Loss of network communication signal.
 - c. Loss of controller signals to inputs and outpoints.
 - d. Operator workstation failure.
 - e. Server failure.
 - f. Gateway failure.
 - g. Network failure.
 - h. Controller failure.
 - i. Instrument failure.
 - j. Control damper and valve actuator failure.
 - k. **<Insert potential failure conditions>**.
 - 4. Complete bibliography of documentation and media to be delivered to Owner.
 - 5. Description of testing plans and procedures.
 - 6. Description of Owner training.
- F. Samples:
 - 1. For each of the following exposed product(s), installed in finished space for approval of selection of aesthetic characteristics:
 - a. Gas instruments specified in Section 230923.16 "Gas Instruments."
 - b. Moisture instruments specified in Section 230923.19 "Moisture Instruments."
 - c. Motion instruments specified in Section 230923.21 "Motion Instruments."
 - d. Pressure instruments specified in Section 230923.23 "Pressure Instruments."
 - e. Temperature instruments specified in Section 230923.27 "Temperature Instruments."
 - f. **<Insert devices>**.
- G. Delegated Design Submittals: For DDC system products and installation indicated as being delegated.
 - 1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
 - 2. Schedule and design calculations for control dampers and actuators.
 - a. Flow at Project design and minimum flow conditions.
 - b. Face velocity at Project design and minimum airflow conditions.

- c. Pressure drop across damper at Project design and minimum airflow conditions.
 - d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
 - e. Maximum close-off pressure.
 - f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.
 - i. Actuator signal to control damper (on, close, or modulate).
 - j. Actuator position on loss of power.
 - k. Actuator position on loss of control signal.
3. Schedule and design calculations for control valves and actuators.
- a. Flow at Project design and minimum flow conditions.
 - b. Pressure-differential drop across valve at Project design flow condition.
 - c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
 - d. Design and minimum control valve coefficient with corresponding valve position.
 - e. Maximum close-off pressure.
 - f. Leakage flow at maximum system pressure differential.
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.
 - i. Actuator signal to control damper (on, close or modulate).
 - j. Actuator position on loss of power.
 - k. Actuator position on loss of control signal.
4. Schedule and design calculations for selecting flow instruments.
- a. Instrument flow range.
 - b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter, and output signal for remote control.
 - c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter, and output signal for remote control.
 - d. Pressure-differential loss across instrument at Project design flow conditions.
 - e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

H. Sustainable Design Submittals:

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

- 1. Plan drawings, reflected ceiling plans, or Building Information Model (BIM), and corresponding product installation details, drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Qualification Statements:

- 1. Systems Provider's Qualification Data:
 - a. Resume of project manager assigned to Project.
 - b. Resumes of application engineering staff assigned to Project.
 - c. Resumes of installation and programming technicians assigned to Project.

- d. Resumes of service technicians assigned to Project.
 - e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity, and building's primary function.
 - f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
 - g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
 - h. Owner contact information for past project including name, phone number, and email address.
 - i. Contractor contact information for past project including name, phone number, and email address.
 - j. Architect[**and Engineer**] contact information for past project including name, phone number, and email address.
 - 2. Manufacturer's qualification data.
 - 3. Testing agency's qualification data.
 - C. Welding certificates.
 - D. Product Certificates:
 - 1. Data Communications Protocol Certificates:
 - a. Certifying that each proposed DDC system component complies with ASHRAE 135.
 - b. Certifying that each proposed DDC system component complies with LonWorks.
 - 2. **<Insert list of products>.**
 - E. Test and Evaluation Reports:
 - 1. Product Test Reports: For DDC system equipment and components, for tests performed by [a **qualified testing agency**][**manufacturer**][**manufacturer and witnessed by a qualified testing agency**].
 - 2. Preconstruction Test Reports: For each separate test performed.
 - F. Source Quality-Control Reports: For DDC system equipment and components.
 - G. Field Quality-Control Reports: For DDC system equipment and components.
 - H. Sample warranty.
- 1.6 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For DDC system.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
 - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, email addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.



- e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
- f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
- g. Engineering, installation, and maintenance manuals that explain how to do the following:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
- h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
- i. Backup copy of graphic files, programs, and databases on electronic media.
- j. List of recommended spare parts with part numbers and suppliers.
- k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
- l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
- m. Licenses, guarantees, and warranty documents.
- n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- o. Owner training materials.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials and parts to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Include product manufacturers' recommended parts lists for proper product operation over **[four]<Insert time>**-year period following warranty period. Parts list to be indicated for each year.
- C. Furnish parts, as indicated by manufacturer's recommended parts list, for product operation during **[one][two]<Insert time>**-year period following warranty period.
- D. Furnish quantity indicated of matching product(s) in Project inventory for each unique size and type of following:
 - 1. Network Controller: **[One]<Insert quantity>**.
 - 2. Programmable Application Controller: **[One]<Insert quantity>**.
 - 3. Application-Specific Controller: **[One]<Insert quantity>**.
 - 4. General-Purpose Relay: **[One]<Insert quantity>**.
 - 5. Multifunction Time-Delay Relay: **[One]<Insert quantity>**.
 - 6. Latching Relay: **[One]<Insert quantity>**.
 - 7. Current-Sensing Relay: **[One]<Insert quantity>**.
 - 8. Combination On-Off Status Sensor and On-Off Relay: **[One]<Insert quantity>**.
 - 9. Transformer: **[One]<Insert quantity>**.
 - 10. DC Power Supply: **[One]<Insert quantity>**.
 - 11. **<Insert product>**.

1.8 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of **[five][10]<Insert number>** years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least **[three][five]<Insert number>** past projects.
4. Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for DDC system installation training, commissioning, and troubleshooting of installations.
 - e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. In-place facility located within **<Insert distance>** of Project.
3. Demonstrate past experience with installation of DDC system products being installed for period within **[three][five]<Insert number>** consecutive years before time of bid.
4. Demonstrate past experience on **[five]<Insert number>** projects of similar complexity, scope, and value.
5. Demonstrate past experience of each **[person]<Insert requirement>** assigned to Project.
6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
7. Service and maintenance staff assigned to support Project during warranty period.
8. Product parts inventory to support ongoing DDC system operation for a period of not less than **[five]<Insert number>** years after Substantial Completion.
9. DDC system manufacturer's backing to take over execution of the Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

D. Welding Qualifications: Qualify procedures and personnel in accordance with the following welding codes:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.
3. AWS D1.3/D1.3M.
4. AWS D1.4/D1.4M.

E. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code.

1.9 MOCKUPS

- A. Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, to set quality standards for materials and execution, and to set quality standards for fabrication and installation.
 - 1. Build mockups of completed installation where products are exposed to view and are located in areas with aesthetic requirements that warrant special attention, including the following spaces:
 - a. **<Insert specific locations for mockups>.**
 - 2. Build mockups of completed installation for areas as indicated on Drawings.
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.
 - 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.10 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: **[Owner will engage][Engage]** a qualified testing agency to perform preconstruction testing on field mockups.
 - 1. **<Insert configurations of assemblies>.**
 - 2. Provide test assemblies representative of proposed materials and construction.
 - 3. Build laboratory mockups at testing agency facility; use personnel, materials, and methods of construction that will be used at Project site.
 - 4. Notify Architect **[seven]<Insert number>** days in advance of dates and times when laboratory mockups will be tested.
- B. Preconstruction Testing: Performed by a qualified testing agency on manufacturer's standard assemblies.
 - 1. **<Insert preconstruction requirements>.**

1.11 WARRANTY

- A. Special Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
 - 1. Adjust, repair, or replace failures at no additional cost or reduction in service to Owner.
 - 2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
 - a. Install updates only after receiving Owner's written authorization.
 - 3. Perform warranty service during normal business hours and commence within **[8][16][24]<Insert number>** hours of Owner's warranty service request.
 - 4. Warranty Period: **[Two]<Insert number>** year(s) from date of Substantial Completion.
 - a. For Gateway: **[Two][Three]<Insert number>**-year parts and labor warranty for each.



PART 2 - PRODUCTS

2.1 DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[ABB, Electrification Business]**
2. **[Alerton Inc.]**
3. **[Automated Logic Corporation]**
4. **[Delta Controls Inc]**
5. **[Distech Controls]**
6. **[Honeywell International Inc.]**
7. **[Johnson Controls, Inc.]**
8. **[KMC Controls, Inc.]**
9. **[Reliable Controls Corporation]**
10. **[Schneider Electric USA, Inc.]**
11. **[Siemens Industry, Inc., Building Technologies Division]**
12. **[Trane]**
13. **<Insert manufacturer's name>**

2.2 DDC SYSTEM DESCRIPTION

- A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.
1. DDC system consisting of **[high-speed,]** peer-to-peer network of distributed DDC controllers, **other network devices]**, operator interfaces, and software.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WEB ACCESS

- A. DDC system to be **[web based][or][web compatible]**.
1. Web-Based Access to DDC System:
 - a. DDC system software based on server thin-client architecture, designed around open standards of web technology. DDC system server accessed using a web browser over DDC system network, using Owner's LAN, and remotely over Internet **[through Owner's LAN]**.
 - b. Intent of thin-client architecture is to provide operators complete access to DDC system via a web browser. No special software other than a web browser is required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
 - c. Password-protected web access.
 2. Web-Compatible Access to DDC System:



- a. **[Workstation][and][or][server]** to perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
- b. DDC system to support web browser access to building data. Operator using a standard web browser is able to access control graphics and change adjustable set points.
- c. Password-protected web access.

2.4 PERFORMANCE REQUIREMENTS

- A. Delivery of Selected Control Devices: Deliver to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.
- B. Delegated Design, Qualified Professional Engineer: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design DDC system to satisfy requirements indicated.
- C. Delegated Design, Qualified Professional: Engage a qualified professional to design DDC system to satisfy requirements indicated.
 1. System Performance Objectives:
 - a. DDC system manages HVAC systems.
 - b. DDC system operates HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
 - c. DDC system responds to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
 - d. DDC system operates while unattended by an operator and through operator interaction.
 - e. DDC system records trends and transactions of events and produces report information such as performance, energy, occupancies, and equipment operation.
- D. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths complying with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 1. Flame-Spread Index: **[25]<Insert value>** or less.
 2. Smoke-Developed Index: **[50]<Insert value>** or less.
- E. DDC System Speed:
 1. Response Time of Connected I/O:
 - a. Update AI point values connected to DDC system at least every **[five][two]** seconds for use by DDC controllers. Points used globally to also comply with this requirement.
 - b. Update BI point values connected to DDC system at least every **[five][two]<Insert number>** seconds for use by DDC controllers. Points used globally to also comply with this requirement.
 - c. AO points connected to DDC system to begin to respond to controller output commands within **[two][one]** second(s). Global commands to also comply with this requirement.
 - d. BO point values connected to DDC system to respond to controller output commands within **[two][one]<Insert number>** second(s). Global commands to also comply with this requirement.
 2. Display of Connected I/O:
 - a. Update and display analog point COV connected to DDC system at least every



- 2026

errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Energy:
 - a. Thermal: Within [5][3][1]<Insert number> percent of reading.
 - b. Electric Power: Within [1]<Insert number> percent of reading.
 - c. Requirements indicated on Drawings for meters not supplied by utility.
2. Flow:
 - a. Air: Within [5][2]<Insert number> percent of design flow rate.
 - b. Air (Terminal Units): Within [10][5]<Insert number> percent of design flow rate.
 - c. Fuel Oil: Within [2][5]<Insert number> percent of design flow rate.
 - d. Natural Gas: Within [2][5]<Insert number> percent of design flow rate.
 - e. Water: Within [2][5]<Insert number> percent of design flow rate.
 - f. Steam: Within [5]<Insert number> percent of design flow rate.
3. Gas:
 - a. Carbon Dioxide: Within [50]<Insert value> ppm.
 - b. Carbon Monoxide: Within [5]<Insert number> percent of reading.
 - c. Oxygen: Within [5]<Insert number> percent of reading.
 - d. Refrigerant: Within [5]<Insert number> percent of reading.
 - e. VOCs: Within [5]<Insert number> percent of reading.
4. Moisture (Relative Humidity):
 - a. Air: Within [5][2]<Insert number> percent RH.
 - b. Space: Within [5][2]<Insert number> percent RH.
 - c. Outdoor: Within [5][2]<Insert number> percent RH.
5. Level: Within [5][2]<Insert number> percent of reading.
6. Pressure:
 - a. Air, Ducts and Equipment: [1][0.5]<Insert number> percent of instrument [range][span].
 - b. Space: Within [1][0.5][0.25]<Insert number> percent of instrument [range][span].
 - c. Water: Within [1][0.5][0.25]<Insert number> percent of instrument [range][span].
 - d. Steam: Within [1][0.5][0.25]<Insert number> percent of instrument [range][span].
7. Speed: Within [10][5]<Insert number> percent of reading.
8. Temperature, Dew Point:
 - a. Air: Within [1 deg F][0.5 deg F]<Insert value>.
 - b. Space: Within [1 deg F][0.5 deg F]<Insert value>.
 - c. Outdoor: Within [3 deg F][2 deg F]<Insert value>.
9. Temperature, Dry Bulb:
 - a. Air: Within [1 deg F][0.5 deg F]<Insert value>.
 - b. Space: Within [1 deg F][0.5 deg F]<Insert value>.
 - c. Outdoor: Within [2 deg F][1 deg F]<Insert value>.
 - d. Chilled Water: Within [1 deg F][0.5 deg F]<Insert value>.
 - e. Condenser Water: Within [1 deg F][0.5 deg F]<Insert value>.
 - f. Heating Hot Water: Within [1 deg F][0.5 deg F]<Insert value>.
 - g. Energy Recovery Runaround Liquid: Within [1 deg F][0.5 deg F]<Insert value>.

- h. Steam: Within [2 deg F][1 deg F]<Insert value>.
 - i. Temperature Difference: Within [0.1 deg F][0.25 deg F]<Insert value>.
 - j. <Insert system>.
 - k. Other Temperatures Not Indicated: Within [1 deg F][0.5 deg F]<Insert value>.
 - 10. Temperature, Wet Bulb:
 - a. Air: Within [1 deg F][0.5 deg F]<Insert value>.
 - b. Space: Within [1 deg F][0.5 deg F]<Insert value>.
 - c. Outdoor: Within [2 deg F][1 deg F]<Insert value>.
 - 11. Vibration: Within [5][10]<Insert number> percent of reading.
- K. Precision of I/O Reported Values: Values reported in database and displayed to have following precision:
 - 1. Current:
 - a. Milliamperes: Nearest 1/100th of a milliampere.
 - b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.
 - 2. Energy:
 - a. Electric Power:
 - 1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
 - 2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
 - 3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
 - b. Fuel Oil (Usage): For gallons, nearest 1/10th of a gallon up to 100 gal.; nearest gallon for above 100 gal..
 - c. Natural Gas (Usage): Nearest 1/10th of a unit (cubic feet, MCF, therm) up to 100 units; nearest unit for above 100 units.
 - d. Thermal, Rate:
 - 1) Heating: For British thermal units per hour, nearest British thermal unit per hour up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For MBh, round to nearest MBh up to 1000 MBh; nearest 10 MBh between 1000 and 10,000 MBh; nearest 100 MBh above 10,000 MBh.
 - 2) Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons.
 - e. Thermal, Usage:
 - 1) Heating: For British thermal unit, nearest British thermal unit up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For MBtu, round to nearest MBtu up to 1000 MBtu; nearest 10 MBtu between 1000 and 10,000 MBtu; nearest 100 MBtu above 10,000 MBtu.
 - 2) Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above 10,000 tons.
 - 3. Flow:

- a. Air: Nearest 1/10th of a cubic feet per minute through 100 cfm; nearest cubic feet per minute between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
 - b. Fuel Oil: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm.
 - c. Natural Gas: Nearest 1/10th of a cubic feet per hour through 100 cfh; nearest cubic feet per hour between 100 and 1000 cfh; nearest 10 cfh between 1000 and 10,000 cfh; nearest 100 cfh above 10,000 cfh.
 - d. Water: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.
 - e. Steam: Nearest 1/10th of a pound per hour through 100 lb/h; nearest pound per hour between 100 and 1000 lb/h; nearest 10 lb/h above 1000 lb/h.
4. Gas:
- a. Carbon Dioxide (ppm): Nearest ppm.
 - b. Carbon Monoxide (ppm): Nearest ppm.
 - c. Oxygen (Percentage): Nearest 1/10th of 1 percent.
 - d. Refrigerant (ppm): Nearest ppm.
 - e. Volatile Organic Compounds (ppm): Nearest ppm
5. Moisture (Relative Humidity):
- a. Relative Humidity (Percentage): Nearest 1 percent.
6. Level: Nearest 1/100th of an inch through 10 inches; nearest 1/10 of an inch between 10 and 100 inches; nearest inch above 100 inches.
7. Speed:
- a. Rotation (rpm): Nearest 1 rpm.
 - b. Velocity: Nearest 1/10th of feet per minute through 100 fpm; nearest feet per minute between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.
8. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
9. Pressure:
- a. Air, Ducts and Equipment: Nearest 1/10th of an inch water closet.
 - b. Space: Nearest 1/100th of an inch water closet.
 - c. Steam: Nearest 1/10th of pounds per square inch gauge through 100 psig; nearest pounds per square inch gauge above 100 psig.
 - d. Water: Nearest 1/10 of a pound per square inch gauge through 100 psig; nearest pound per square inch gauge above 100 psig.
10. Temperature:
- a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
 - b. Outdoor: Nearest degree.
 - c. Space: Nearest 1/10th of a degree.
 - d. Chilled Water: Nearest 1/10th of a degree.
 - e. Condenser Water: Nearest 1/10th of a degree.
 - f. Heating Hot Water: Nearest degree.
 - g. Heat Recovery Runaround: Nearest 1/10th of a degree.
 - h. Steam: Nearest degree.

11. Vibration: **Nearest 1/10th of an inch per second.**
 12. Voltage: Nearest 1/10 V up to 100 V; nearest volt above 100 V.
- L. Control Stability: Control variables indicated within the following limits:
1. Flow:
 - a. Air, Ducts and Equipment, except Terminal Units: Within [5][2]<Insert number> percent of design flow rate.
 - b. Air, Terminal Units: Within [10][5]<Insert number> percent of design flow rate.
 - c. Water: Within [2][5]<Insert number> percent of design flow rate.
 - d. Steam: Within [5]<Insert number> percent of design flow rate.
 2. Gas:
 - a. Carbon Dioxide: Within [50]<Insert value> ppm.
 - b. Carbon Monoxide: Within [5]<Insert number> percent of reading.
 - c. Oxygen: Within [5]<Insert number> percent of reading.
 3. Moisture (Relative Humidity):
 - a. Air: Within [5][2]<Insert number> percent RH.
 - b. Space: Within [5][2]<Insert number> percent RH.
 - c. Outdoor: Within [5][2]<Insert number> percent RH.
 4. Level: Within [5][2]<Insert number> percent of reading.
 5. Pressure:
 - a. Air, Ducts and Equipment: [1][0.5]<Insert number> percent of instrument [range][span].
 - b. Space: Within [1][0.5][0.25]<Insert number> percent of instrument [range][span].
 - c. Water: Within [1][0.5][0.25]<Insert number> percent of instrument [range][span].
 - d. Steam: Within [1][0.5][0.25]<Insert number> percent of instrument [range][span].
 6. Temperature, Dew Point:
 - a. Air: Within [1 deg F][0.5 deg F]<Insert value>.
 - b. Space: Within [1 deg F][0.5 deg F]<Insert value>.
 7. Temperature, Dry Bulb:
 - a. Air: Within [2 deg F][1 deg F][0.5 deg F]<Insert value>.
 - b. Space: Within [2 deg F][1 deg F][0.5 deg F]<Insert value>.
 - c. Chilled Water: Within [1 deg F][0.5 deg F]<Insert value>.
 - d. Condenser Water: Within [1 deg F][0.5 deg F]<Insert value>.
 - e. Heating Hot Water: Within [2 deg F][1 deg F][0.5 deg F]<Insert value>.
 - f. Energy Recovery Runaround Liquid: Within [1 deg F][0.5 deg F]<Insert value>.
 - g. <Insert system>.
 8. Temperature, Wet Bulb:
 - a. Air: Within [1 deg F][0.5 deg F]<Insert value>.
 - b. Space: Within [1 deg F][0.5 deg F]<Insert value>.
- M. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products to operate without performance degradation under ambient environmental temperature, pressure, and humidity conditions encountered for installed location.
 - a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure to be internally insulated, electrically heated, cooled, and ventilated as required by product and application.
2. Protect products with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House products not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location dictates the following NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: **[Type 2][Type 3][Type 12]<Insert type>**.
 - b. Outdoors, Unprotected: **[Type 4][Type 4X]**.
 - c. Indoors, Heated with Filtered Ventilation: **[Type 1][Type 2]<Insert type>**.
 - d. Indoors, Heated with Non-Filtered Ventilation: **[Type 2][Type 12]<Insert type>**.
 - e. Indoors, Heated and Air-Conditioned: **[Type 1]<Insert type>**.
 - f. Mechanical Equipment Rooms:
 - 1) Chiller and Boiler Rooms: **[Type 12][Type 4][Type 4X]<Insert type>**.
 - 2) Air-Moving Equipment Rooms: **[Type 1][Type 2][Type 12]<Insert type>**.
 - g. Localized Areas Exposed to Washdown: **[Type 4][Type 4X]<Insert type>**.
 - h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: **[Type 2][Type 3][Type 12]<Insert type>**.
 - i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: **[Type 4][Type 4X]<Insert type>**.
 - j. Hazardous Locations: Explosion-proof rating for condition.
 - k. **<Insert location and enclosure requirements>**.

N. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators to operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure is internally insulated, electrically heated[, **cooled**], and ventilated as required by instrument and application.
2. Protect instruments, actuators, and accessories with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House instruments and actuators not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location is to dictate the following NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: **[Type 2][Type 3][Type 12]<Insert type>**.
 - b. Outdoors, Unprotected: **[Type 4][Type 4X]**.
 - c. Indoors, Heated with Filtered Ventilation: **[Type 1][Type 2]<Insert type>**.
 - d. Indoors, Heated with Non-Filtered Ventilation: **[Type 2][Type 12]<Insert type>**.
 - e. Indoors, Heated and Air-conditioned: **[Type 1]<Insert type>**.
 - f. Mechanical Equipment Rooms:

- 1) Chiller and Boiler Rooms: [Type 12][Type 4][Type 4X]<Insert type>.
 - 2) Air-Moving Equipment Rooms: [Type 1][Type 2][Type 12]<Insert type>.
 - g. Localized Areas Exposed to Washdown: [Type 4][Type 4X]<Insert type>.
 - h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: [Type 2][Type 3][Type 12]<Insert type>.
 - i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: [Type 4][Type 4X]<Insert type>.
 - j. Hazardous Locations: Explosion-proof rating for condition.
 - k. <Insert location and enclosure requirements>.
- O. DDC System Reliability:
1. Design, install, and configure DDC controllers, [gateways],[routers],[and]<Insert product> to yield a MTBF of at least [40,000][20,000]<Insert number> hours, based on a confidence level of at least [90]<Insert number> percent. MTBF value includes any failure for any reason to any part of products indicated.
 2. If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment being controlled, operational, and under automatic control.
 3. See Drawings for critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated.
- P. Electric Power Quality:
1. Power-Line Surges:
 - a. Protect [susceptible]DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.1 and IEEE C62.41.2.
 - b. Do not use fuses for surge protection.
 - c. Test protection in the normal mode and in the common mode, using the following two waveforms:
 - 1) 10-by-1000-microsecond waveform with a peak voltage of 1500 V and a peak current of 60 A.
 - 2) 8-by-20-microsecond waveform with a peak voltage of 1000 V and a peak current of 500 A.
 2. Power Conditioning:
 - a. Protect [susceptible]DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner are as follows:
 - 1) At 85 percent load, output voltage to not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
 - 2) During load changes from zero to full load, output voltage to not deviate by more than [2][3]<Insert number> percent of nominal.
 - 3) Accomplish full correction of load switching disturbances within [five]<Insert number> cycles, and 95 percent correction within [two]<Insert number> cycles of onset of disturbance.
 - 4) Total harmonic distortion to not exceed [2][3]<Insert number> percent at full load.
 3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products to not fail due to ground fault condition.

Q. Backup Power Source:

1. Serve DDC system products that control HVAC systems and equipment served by a backup power source also from a backup power source.

R. UPS:

1. DDC system products powered by UPS units are to include the following:
 - a. Servers.
 - b. Gateways.
 - c. DDC controllers[, **except application-specific controllers**].
 - d. Desktop workstations.
 - e. **<Insert equipment>**.
2. DDC system instruments and actuators powered by UPS units are to include the following:
 - a. Instruments: [**Where indicated on Drawings**];where associated with the following systems controlled by DDC system:
 - 1) **<Insert list of systems>**.
 - b. Damper Actuators: [**Where indicated on Drawings**];where associated with the following systems controlled by DDC system:
 - 1) **<Insert list of systems>**.
 - c. Valve Actuators: [**Where indicated on Drawings**];where associated with the following systems controlled by DDC system:
 - 1) **<Insert list of systems>**.

S. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems are to automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 PANEL-MOUNTED, MANUAL OVERRIDE SWITCHES

A. Manual Override of Control Dampers:

1. Include panel-mounted, two-position, selector switch for each automatic control damper being controlled by DDC controller.
2. Label each switch with damper designation served by switch.
3. Label switch positions to indicate either "Manual" or "Auto" control signal to damper.
4. With switch in "Auto" position, control signal to damper actuator with control loop output signal from DDC controller.
5. With switch in "Manual" position, control signal to damper actuator at panel with either an integral or a separate switch to include local control.

- a. For Binary Control Dampers: Manual two-position switch with "Close" and "Open" switch positions indicated. With switch in "Close" position, close damper. With switch in "Open" position, open damper.
 - b. For Analog Control Dampers: A gradual switch with "Close" and "Open" switch limits indicated. Operator switches knob to adjust damper to any position from close to open.
6. DDC controller to monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller to signal an override condition to alert operator that damper is under manual, not automatic, control.
 7. Configure manual override switches to allow operator to manually operate damper while at panel without DDC controller **[installed][and][operational]**.
 8. Terminal equipment including **[VAV units],[fan-coil units],[and][unit heaters]** do not require manual override unless otherwise indicated by sequence of operation.

B. Manual Override of Control Valves:

1. Include panel-mounted, two-position, selector switch for each automatic control valve being controlled by DDC controller.
 2. Label each switch with valve designation served by switch.
 3. Label switch positions to indicate either "Manual" or "Auto" control signal to valve.
 4. With switch in "Auto" position, control signal to valve actuator with a control loop output signal from DDC controller.
 5. With switch in "Manual" position, control signal to valve actuator at panel with either an integral or a separate switch to include local control.
- a. For Binary Control Valves: Manual two-position switch with "Close" and "Open" switch positions indicated. With switch in "Close" position, close valve. With switch in "Open" position, open valve.
 - b. For Analog Control Valves: A gradual switch with "Open" and "Close" switch limits indicated. Operator rotates switch knob to adjust valve to any position from close to open.
6. DDC controller to monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller to signal an override condition to alert operator that valve is under manual, not automatic, control.
 7. Configure manual override switches to allow operator to manually operate valve while at panel without DDC controller **[installed][and][operational]**.
 8. Terminal equipment including **[VAV units],[fan-coil units],[and][unit heaters]** do not require manual override unless otherwise indicated by sequence of operation.

2.6 SYSTEM ARCHITECTURE

A. System architecture consisting of no more than **[two][or][three]<Insert number>** levels of LANs.

1. Level 2 LAN: Connect network controllers and operator workstations.
2. Level 1 or Level 2 LAN: Connect **[Level 1][or][Level 2]** programmable application controllers to other programmable application controllers and to network controllers.
3. Level 2 or Level 3 LAN: Connect **[Level 2][or][Level 3]** application-specific controllers to **[programmable application controllers and to network controllers][application-specific controllers]**.

B. Minimum Data Transfer and Communication Speed:

1. LAN Connecting Operator Workstations and Network Controllers: **[100][10][2.5][1.25]<Insert value>** Mbps.
2. LAN Connecting Programmable Application Controllers: **[1000][100]<Insert value>** kbps.

3. LAN Connecting Application-Specific Controllers: [115,000][76,800][38,400][19,200]<Insert value> bps.

- C. Provide dedicated[**and separated**] DDC system LANs that are not shared with other building systems and tenant data and communication networks.
- D. Provide modular system architecture with inherent ability to expand to not less than [1.25][1.5][two]<Insert number> times system size indicated with no impact to performance indicated.
- E. Configure architecture to [eliminate][or][minimize] need to remove and replace existing network equipment for system expansion.
- F. Make number of LANs and associated communication transparent to operator. Configure all I/O points residing on any LAN to be capable of global sharing between all system LANs.
- G. Design system to eliminate dependence on any single device for system alarm reporting and control execution. Design each controller to operate independently by performing own control, alarm management, and historical data collection.
- H. Special Network Architecture Requirements:
 - 1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling-system air-handling unit(s). Basically, create DDC system LAN that aligns with air-handling system being controlled.
 - 2. <Insert additional requirements>.

2.7 DDC SYSTEM OPERATOR INTERFACES

- A. Operator Means of System Access: Operator able to access entire DDC system through any of multiple means including, but not limited to, the following:
 - 1. Desktop and portable workstation with hardwired connection through LAN port.
 - 2. Portable operator terminal with hardwired connection through LAN port.
 - 3. Portable operator workstation with wireless connection through LAN router.
 - 4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
 - 5. Remote connection through web access.
- B. Make access to system, regardless of operator means used, transparent to operator.
- C. Network Ports: For hardwired connection of desktop or portable workstation. Network port easily accessible, properly protected, clearly labeled, and installed at the following locations:
 - 1. Each mechanical equipment room.
 - 2. Each boiler room.
 - 3. Each chiller room.
 - 4. Each outdoor on-grade yard and elevated platform with equipment connected to DDC system.
 - 5. Each different roof level with roof-mounted equipment connected to DDC system.
 - 6. Security system command center.
 - 7. Fire-alarm system command center.
 - 8. <Insert additional locations>.

D. Desktop Workstations:

1. Connect **[Owner-furnished]**desktop workstation(s) to DDC system Level 1 LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.

E. Portable Workstations:

1. Connect **[Owner-furnished]**portable workstation(s) to DDC system Level 1 LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.
3. Connect to DDC system **[Level 2][or][Level 3]** LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
4. Connect to system through a wireless router connected to Level 1 LAN.
5. Connect to system through a cellular broadband data service.
6. Portable workstation able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
7. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
8. Have dynamic graphic displays that are identical to desktop workstations.

F. POT:

1. Connect DDC controller through a communications port local to controller.
2. Able to communicate with any DDC system controller that is directly connected **[or with LAN][or connected to DDC system]**.

G. Mobile Device (Tablet and Smart Phone):

1. Connect Owner-furnished mobile devices to system through a wireless router connected to LAN**[and cellular data service]**.
2. Able to communicate with any DDC controller connected to DDC system using **[dedicated application][and][secure web access]**.

H. Critical Alarm Reporting:

1. Send operator-selected critical alarms to notify operator of critical alarms that require immediate attention.
2. Send alarm notification to multiple recipients that are assigned for each alarm.
3. Notify recipients by any or all means, including email, text message, and prerecorded phone message to mobile and landline phone numbers.

- I. Simultaneous Operator Use: Capable of accommodating up to **[five][10][20]<Insert number>** simultaneous operators that are accessing DDC system through any of operator interfaces indicated.

2.8 NETWORKS

A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:

1. ATA 878.1, ARCNET.
2. CTA-709.1-D.
3. IP.
4. ISO/IEC/IEEE 8802-3, Ethernet.

5. <Insert type>.

B. Acceptable networks for connecting programmable application controllers include the following:

1. ATA 878.1, ARCNET.
2. CTA-709.1-D.
3. IP.
4. ISO/IEC/IEEE 8802-3, Ethernet.
5. <Insert type>.

C. Acceptable networks for connecting application-specific controllers include the following:

1. ATA 878.1, ARCNET.
2. CTA-709.1-D.
3. TIA 485-A.
4. IP.
5. ISO/IEC/IEEE 8802-3, Ethernet.
6. <Insert type>.

2.9 NETWORK COMMUNICATION PROTOCOL

A. Use network communication protocol(s) that are open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. Use ASHRAE 135 communication protocol as sole and native protocol used throughout entire DDC system.
2. DDC system to not require use of gateways except to integrate HVAC equipment and other building systems and equipment; not required to use ASHRAE 135 communication protocol.
3. If used, gateways to connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Use operator workstations, controllers, and other network devices that are tested and listed by BTL.

C. CTA-709.1-D Protocol:

1. Open implementation of LonWorks technology using CTA 709.1-D communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for communication throughout DDC system.
2. Use LNS for all network management including addressing and binding of network variables.
 - a. Submit final LNS database with Project closeout submittals.
 - b. All devices are to be online and commissioned into LNS database.
3. Use CTA-709.1-D protocol for all connected device. Install so SCPT output from any node on network can be bound to any other node in the domain.

D. Industry Standard Protocols:

1. Use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:

- a. ASHRAE 135.
 - b. CTA-709.1-D.
 - c. Modbus Application Protocol Specification V1.1b3.
 - d. **<Insert standard protocol>.**
2. Operator workstations **[and network controllers]** are to communicate through **[ASHRAE 135][or][CTA-709.1-D]** protocol.
 3. Provide portions of DDC system networks using ASHRAE 135 communication protocol as an open implementation of network devices complying with ASHRAE 135. Use network devices that are tested and listed by BTL.
 4. Provide portions of DDC system networks using CTA-709.1-D communication protocol as an open implementation of LonWorks technology using CTA-709.1-D communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for DDC system.
 5. Provide portions of DDC system networks using Modbus Application Protocol Specification V1.1b3 communication protocol as an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b3.
 6. Use gateways to connect networks and network devices with different protocols.

2.10 DDC SYSTEM WIRELESS NETWORKS

- A. Use **[Zigbee][or][an open industry standard and technology used by multiple DDC system manufacturers]<Insert wireless technology>** technology to create a wireless mesh network to provide wireless connectivity for network devices at multiple system levels including communications from programmable application controllers and application-specific controllers to temperature sensors and from network controllers to programmable application controllers and application-specific controllers.
- B. Design and install wireless networks to comply with DDC system performance requirements indicated using wireless network devices that can co-exist on same network with hardwired devices.
- C. Provide hardwired controllers capable of retrofitting to wireless devices with no special software.
- D. Provide a wireless coordinator for wireless interface between programmable application controllers, application-specific controllers, and network controllers.
- E. Wireless Coordinators:
 1. Use for initiation and formation of each wireless mesh network.
 2. Use direct-sequence spread spectrum RF technology.
 3. Operate on 2.4 GHz ISM Band.
 4. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
 5. FCC compliant to 47 CFR 15, Subpart B, Class A.
 6. Operate as a bidirectional transceiver with sensors and routers to confirm and synchronize data transmission.
 7. Capable of communication with sensors and routers up to a maximum distance of **250 ft.** in line of sight.
 8. Include visual indicators to provide diagnostic information required for operator verification of operation.
- F. Wireless Routers:
 1. Use wireless routers with any controller to provide a wireless interface to a network controller, through a wireless coordinator.
 2. Use direct-sequence spread spectrum RF technology.
 3. Operate on 2.4 GHz ISM Band.

4. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
5. FCC compliant to 47 CFR 15, Subpart B, Class A.
6. Operate as a bidirectional transceiver with other mesh network devices to ensure network integrity.
7. Capable of communication with other mesh network devices at a maximum distance of **250 ft.** in line of sight.
8. Include indication for use in commissioning and troubleshooting.

G. Wireless Temperature Sensors:

1. Wireless temperature sensors to sense and transmit room temperatures, temperature set point, room occupancy notification, and low battery condition to an associated router.
2. Use direct-sequence spread spectrum RF technology.
3. Operate on 2.4 GHz ISM Band.
4. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
5. FCC compliant to 47 CFR 15, Subpart B, Class A.
6. Include set-point adjustment between **[55 to 85 deg F]<Insert range>**.
7. Configure so multiple sensors can report to a router connected to DDC controller for averaging or high and low selection.

H. One-to-One Wireless Network Receivers:

1. One-to-one wireless receivers receive wireless RF signals containing temperature data from multiple wireless room temperature sensors and communicate information to programmable application controllers or application-specific controllers.
 - a. Use direct-sequence spread spectrum RF technology.
 - b. Operate on 2.4 GHz ISM Band.
 - c. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
 - d. FCC compliant to 47 CFR 15, Subpart B, Class A.
 - e. Operate as a bidirectional transceiver with sensors to confirm and synchronize data transmission.
 - f. Capable of communication up to a distance of **200 ft.**
 - g. Include visual indication of the following:
 - 1) Power.
 - 2) Receiver activity.
 - 3) Wireless RF transmission from wireless sensors.
 - 4) No transmission, weak signal, adequate signal, or excellent signal.

I. One-to-One Wireless Network Sensors:

1. One-to-one wireless sensors sense and report room temperatures to one-to-one receiver.
 - a. Use direct-sequence spread spectrum RF technology.
 - b. Operate on 2.4 GHz ISM Band.
 - c. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
 - d. FCC compliant to 47 CFR 15, Subpart B, Class A.
 - e. Include set-point adjustment between **55 to 85 deg F**.

2.11 DDC DESKTOP WORKSTATION

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be**

incorporated into the Work include, but are not limited to, the following]:

1. **[Dell Technologies Inc.]**
 2. **[HP Inc.]**
 3. **[Lenovo Holding Co., Inc.; Lenovo Group Ltd.]**
 4. **<Insert manufacturer's name>**
- B. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.
- C. Performance Requirements:
1. May dictate equipment exceeding minimum requirements indicated.
 2. ENERGY STAR compliant.
- D. Personal Computer:
1. Minimum Processor Speed: **<Insert gigahertz>**.
 2. RAM:
 - a. Capacity: **[8]<Insert value>[GB]**.
 - b. Speed and Type: **[1333]<Insert value> MHz, <Insert type>**.
 3. Hard Drive:
 - a. Media: **[Solid state][Rotating disc, nominal rotational speed of 7200 rpm][Hybrid solid-state and rotating disc]**.
 - b. Number of Hard Drives: **[One][Two]<Insert number>**.
 - c. Capacity: **<Insert number and measurement unit>**.
 - d. Minimum Average Seek Time: **<Insert number and measurement unit>**.
 - e. Cache Buffer Size: **<Insert number and measurement unit>**.
 - f. **<Insert requirements>**.
 4. Second Hard Drive:
 - a. Media: **[Solid state][Rotating disc, nominal rotational speed of 7200 rpm][Hybrid solid-state and rotating disc]**.
 - b. Capacity: **<Insert number and measurement unit>**.
 - c. Minimum Average Seek Time: **<Insert number and measurement unit>**.
 - d. Cache Buffer Size: **<Insert number and measurement unit>**.
 - e. **<Insert requirements>**.
 5. Optical Read and Write Drive:
 - a. Include with at least 2 MB of data buffer.
 - b. Type: **<Insert type>**.
 - c. Minimum Data Buffer Capacity: **<Insert number and measurement unit>**.
 - d. Minimum Average Access Time: **<Insert number> ms**.
 - e. Nominal Data Transfer Rates:
 - 1) Reading: **<Insert value>[MB][TB]/s**.
 - 2) Writing: **<Insert value>[MB][TB]/s**.
 - f. Average access time of 150 ms or less.
 - g. MTBF of at least 100,000 power-on hours.

6. At least four expansion slots of [32][64]<Insert number> bit.
7. Video Card:
 - a. Resolution: [1920 by 1200]<Insert values> pixels.
 - b. RAM: <Insert value>[MB][GB][TB].
 - c. Controller Speed: <Insert value>[MHz][GHz].
 - d. On-Board Memory Speed: <Insert value>[MHz][GHz].
 - e. On-Board Memory Data Width: <Insert number> bit.
8. Sound Card:
 - a. At least 128 voice wavetable synthesis.
 - b. Capable of delivering three-dimensional sound effects.
 - c. High-resolution, 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.
9. Network Interface Card: Include card with connection, as applicable.
 - a. 10-100-1000 base TX Ethernet with RJ-45 connector port.
 - b. 100 base FX Ethernet with SC or ST port.
- E. Wireless Ethernet, 802.11 ac:
 1. Optical Modem: Full duplex link for connection to optical fiber cable provided.
 2. I/O Ports:
 - a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
 - b. One serial port.
 - c. One parallel port.
 - d. Two PS/2 ports.
 - e. One RJ-45.
 - f. One stereo line-in and headphone/line-out on back panel.
 - g. One microphone and headphone connector on front panel.
 - h. One IEEE 1394 on front and back panel with PCI-e card.
 - i. One ESATA port on back panel.
 3. Battery: Life of at least three years to maintain system clock/calendar and ROM, at a minimum.
- F. Keyboard:
 1. 101 enhanced keyboard.
 2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
 3. Wireless operation within up to **72 inches** in front of workstation.
- G. Pointing Device:
 1. Two- or three-button mouse.
 2. Wireless operation within up to **72 inches** in front of workstation.
- H. Flat Panel Display Monitor:
 1. Display:

- a. Color display with <Insert inches> diagonal viewable area.
 - b. **[Digital][or][analog]** input signal.
 - c. Aspect Ratio: **[16 to 9]<Insert value>**.
 - d. Antiglare display.
 - e. Response Time: **<Insert number> ms.**
 - f. Dynamic Contrast Ratio: **[50000 to 1]<Insert ratio>**.
 - g. Brightness: **[250 cd/sq. m]<Insert value>**.
 - h. Tilt adjustable base.
 - i. ENERGY STAR compliant.
 - j. Resolution: **[1920 by 1080]<Insert value>** pixels at 60 Hz with pixel size of **[0.277]<Insert number>** mm or smaller.
 - k. Number of Displays: **[One][Two]<Insert number>**.
- I. Speakers:
1. Two, with individual controls for volume, bass and treble.
 2. Signal to Noise Ratio: At least 65 dB.
 3. Power: At least 4 W per speaker/channel.
 4. Magnetic shielding to prevent distortion on the video monitor.
- J. I/O Cabling: Include applicable cabling to connect I/O devices.

2.12 PORTABLE WORKSTATIONS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Dell Technologies Inc.]**
 2. **[HP Inc.]**
 3. **[Lenovo Holding Co., Inc.; Lenovo Group Ltd.]**
 4. **<Insert manufacturer's name>**
- B. Description: A self-contained computer designed to allow for normal use in different locations and conditions.
- C. Performance Requirements:
1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
 2. ENERGY STAR compliant.
 3. Hardware and software to support local downloading to DDC controllers.
 4. Data transfer rate to DDC controller is to be at network speed.
- D. Processor:
1. Minimum Processor Speed: **<Insert gigahertz>**.
 2. RAM:
 - a. Capacity: **<Insert value>[GB][TB]**.
 - b. Speed and Type: **<Insert value> MHz, <Insert type>**.
 3. Hard Drive:
 - a. Number of Hard Drives: **[One][Two]<Insert number>**.
 - b. Capacity: **<Insert number and measurement unit>**.

- c. Minimum Average Seek Time: <Insert number and measurement unit>.
 - d. Cache Buffer Size: <Insert number and measurement unit>.
 - e. <Insert requirements>.
- 4. Video Card: <Insert number and measurement unit> of RAM.
- E. I/O Ports:
 - 1. Serial port.
 - 2. Shared port for external keyboard or mouse.
 - 3. Four USB 3.0 ports.
 - 4. Ethernet port.
 - 5. HDMI port.
 - 6. IEEE 1394 port.
- F. Battery:
 - 1. Capable of supporting operation of portable workstation for a minimum of [8]<Insert number> hours.
 - 2. Battery life of at least three years.
 - 3. Battery charge time of less than three hours.
 - 4. Spare Battery(ies): [One][Two].
- G. Keyboard:
 - 1. 85-key [backlit]keyboard.
 - 2. Full upper- and lowercase ASCII keyset.
- H. Integral Pointing Device: Touchpad with two buttons. Gesture enabled.
- I. Display:
 - 1. <Insert inches> diagonal or larger high-definition WLED color display.
 - 2. Antiglare screen.
 - 3. [1920 by 1080]<Insert value> pixel resolution.
 - 4. Brightness: 300 nits.
- J. Network Interfaces:
 - 1. Network Interface Card: Include card with connection, as application.
 - a. 10-100-1000 base TX Ethernet with RJ-45 connector port.
 - b. 100 base FX Ethernet with SC or ST port.
 - 2. Wireless:
 - a. Internal with integrated antenna, capable of supporting WiFi standards 802.11 a/b/g/n.
- K. Digital Video Disc Rewrite Recorder (DVD+/-RW):
 - 1. Compatible with DVD discs and data, audio, recordable, and rewritable compact discs.
 - 2. Nominal Data Transfer Rates:
 - a. Reading: <Insert number>[MB][TB]/s.

- b. Writing: <Insert number>[MB][TB]/s.
- 3. 160-ms access time.
- L. Accessories:
 - 1. Nylon carrying case.
 - 2. Docking station.
 - 3. Mobile broadband card.
 - 4. Wireless optical mouse.
 - 5. <Insert value>[GB][TB] portable hard drive.
 - 6. Light-sensitive web cam and noise-cancelling digital array microphone.
 - 7. Category 6a patch cable. Minimum cable length is to be <Insert length>.
 - 8. HDMI cable. Minimum cable length is to be <Insert length>.
 - 9. <Insert accessories>.

2.13 PORTABLE OPERATOR TERMINALS

- A. Description: Handheld device with integral keypad or touch screen operator interface.
- B. Display: Multiple lines of text display for use in operator interaction with DDC system.
- C. Cable: Flexible [coiling]cable, at least **36 inches** long, with a plug-in jack for connection to DDC controllers, network ports, or instruments with an integral LAN port. As an alternative to hardwired connection, POTs may be accessible to DDC controllers through a wireless network connection.
- D. Power POTs through network connection.
- E. Connection of POTs to DDC system to not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or preclude central initiated commands and system modification.
- F. POTs to give operator ability to do the following:
 - 1. Display and monitor BI point status.
 - 2. Change BO point set point (on or off, open or closed).
 - 3. Display and monitor analog point values.
 - 4. Change analog control set points.
 - 5. Command a setting of AO point.
 - 6. Display and monitor I/O point in alarm.
 - 7. Add a new or delete an existing I/O point.
 - 8. Enable and disable I/O points, initiators, and programs.
 - 9. Display and change time and date.
 - 10. Display and change time schedules.
 - 11. Display and change run-time counters and run-time limits.
 - 12. Display and change time and event initiation.
 - 13. Display and change control application and DDC parameters.
 - 14. Display and change programmable offset values.
 - 15. Access DDC controller initialization routines and diagnostics.
 - 16. <Insert requirements>.

2.14 SERVERS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide

products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Dell Technologies Inc.]
2. [HP Inc.]
3. [Lenovo Holding Co., Inc.; Lenovo Group Ltd.]
4. <Insert manufacturer's name>

B. Description: x86-based permanently installed computer used for client-server computing.

C. Mounting: [Rack][Blade][Tower][Tower able to be rack mounted].

D. Power: [Single][Dual] power supply, minimum [300]<Insert value> W.

E. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. ENERGY STAR compliant.
3. Minimum Processor Speed: <Insert gigahertz>.
4. RAM:
 - a. Capacity: <Insert value>[GB][TB].
 - b. Speed and Type: <Insert value> MGz, <Insert type>.
 - c. Expandable Capacity: <Insert value>[GB][TB].
5. Redundant Array of Independent Discs: [Zero][One][Two][Three][Four][Five]<Insert number> configuration.
6. Drive Bays: Eight at **2.5 inches** or eight at **3.5 inches**.
7. Hard-Drive Storage: [Two][Three][Four] drives each with <Insert value>[GB][TB] storage and nominal rotational speed of 7200 rpm.
8. Network Interface: [Dual-port gigabit Ethernet][Optical fiber].
9. DVD +RW drive.
10. Color, flat-screen display with <Insert inches> diagonal viewable area.
11. Keyboard and mouse.
12. Next-day on-site warranty for [two][three]<Insert number>-year period following Substantial Completion.

F. Servers are to include the following:

1. Full-feature backup server (server and backup minimum requirement).
2. Software licenses.
3. Cable installation between server(s) and network.

G. Web Server:

1. If required to be separate, include web server hardware and software to match, except backup server is not required.
2. Firewalls between server web and networks.
3. Password protection for access to server from web server.
4. Cable installation between the server(s) and building Ethernet network.

H. Power each server through a [dedicated]UPS unit.

2.15 PRINTERS

A. Black and White Laser Printer:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Brother International Corporation]**
 - b. **[Epson America, Inc.]**
 - c. **[Hewlett-Packard Company]**
 - d. **<Insert manufacturer's name>**
2. **[1200 by 1200]<Insert value>** dots per inch resolution.
3. First sheet printed within 10 seconds.
4. **<Insert number>** page per minute rated print speed at best quality mode.
5. Print buffer with at least **<Insert value>** MB of RAM, expandable to at least 288 MBs.
6. Complies with ENERGY STAR requirements.
7. Capable of handling letter- and legal-size paper and overhead transparencies.
8. Two paper trays; one tray with **<Insert number>** sheet capacity, and one tray with **<Insert number>** sheet capacity.
9. At least **<Insert number>** page toner/cartridge capacity.

B. Color Laser Printer:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Brother International Corporation]**
 - b. **[Epson America, Inc.]**
 - c. **[Hewlett-Packard Company]**
 - d. **<Insert manufacturer's name>**
2. **[1200 by 1200]<Insert value>** dots per inch resolution black and white, **[1200 by 1200]<Insert value>** dots per inch resolution black and white and color.
3. First sheet printed within 10 seconds.
4. **<Insert number>** page per minute rated print speed at best quality mode.
5. Print buffer with at least **[512]<Insert value>** MB of RAM, expandable to at least **[one]<Insert value>** GB.
6. Complies with ENERGY STAR requirements.
7. Capable of handling letter- and legal-size paper and overhead transparencies.
8. Two paper trays; one tray with **<Insert number>** sheet capacity, and one tray with 500 **<Insert number>** sheet capacity.
9. Two-sided printing.
10. At least **<Insert number>** page toner/cartridge capacity.

C. Color Inkjet Printer:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. **[Brother International Corporation]**
 - b. **[Epson America, Inc.]**
 - c. **[Hewlett-Packard Company]**
 - d. **<Insert manufacturer's name>**
2. Inkjet technology with true four-color printing (black, cyan, magenta, and yellow).
 3. Print quality of **[1200 by 600]<Insert value>** dots per inch with black on inkjet paper and **[4800 by 1200]<Insert value>** dots per inch color printing on premium photo paper.
 4. Rated speed of **<Insert number>** pages per minute printing black and white in normal mode and **<Insert number>** pages per minute printing color in normal mode.
 5. Two paper trays; one tray with **<Insert number>** sheet capacity, and one tray with **<Insert number>** sheet capacity.
 6. Capable of handling letter- and legal-size paper and overhead transparencies.
 7. **<Insert value>** MB of RAM.
 8. Duplex printing (printing on both sides of paper).

D. Dot Matrix Printer:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Epson America, Inc.]**
 - b. **[OKI Data Americas]**
 - c. **<Insert manufacturer's name>**
2. Letter-quality, wide-carriage, 24-pin dot matrix printer.
3. **<Insert number>** kb print buffer.
4. Minimum Print Speed:
 - a. **<Insert number>** characters per second (draft).
 - b. **<Insert number>** characters per second (letter quality).
5. **[Seven]<Insert number>** print fonts.
6. Continuous - forms feed with manual single sheet feed.
7. Capable of handling **16-inch-** wide continuous-feed paper.

2.16 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser **[32-][or][64-]**bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system capable of operating DOS and Microsoft Windows applications.
3. Database management software to manage all data on an integrated and non-redundant basis. Additions and deletions to database are to be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software to manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software to include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and

- online data modification capability.
- 6. Scheduling software to schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

- 1. Minimize operator training through use of English language prorating and English language point identification.
- 2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
- 3. Make operator sign-off a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
- 4. Make automatic sign-off period programmable from one to 60 minutes in one-minute increments on a per operator basis.
- 5. Record operator sign-on and sign-off activity and send to printer.
- 6. Security Access:
 - a. Use password control for operator access to DDC system.
 - b. Assign an alphanumeric password (field assignable) to each operator.
 - c. Grant operators access to DDC system by entry of proper password.
 - d. Use same operator password regardless of which computer or other operator interface means are used.
 - e. Automatically update additions or changes made to passwords.
 - f. Assign each operator an access level to restrict access to data and functions the operator is cable of performing.
 - g. Provide software with at least five access levels.
 - h. Assign each menu item an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
 - i. Display menu items to operator with those capable of access highlighted. Make menu and operator access level assignments online programmable and under password control.
- 7. Data Segregation:
 - a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
 - b. Include at least [32]<Insert number> segregation groups.
 - c. Make segregation groups selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
 - d. Make points assignable to multiple segregation groups. Display and output of data to printer or monitor is to occur where there is a match of operator or peripheral segregation group assignment and point segregations.
 - e. Make alarms displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
 - f. Assign operators and peripherals to multiple segregation groups and make all assignments online programmable and under password control.
- 8. Operators able to perform commands including, but not limited to, the following:
 - a. Start or stop selected equipment.
 - b. Adjust set points.
 - c. Add, modify, and delete time programming.
 - d. Enable and disable process execution.
 - e. Lock and unlock alarm reporting for each point.
 - f. Enable and disable totalization for each point.
 - g. Enable and disable trending for each point.

- h. Override control loop set points.
- i. Enter temporary override schedules.
- j. Define holiday schedules.
- k. Change time and date.
- l. Enter and modify analog alarm limits.
- m. Enter and modify analog warning limits.
- n. View limits.
- o. Enable and disable demand limiting.
- p. Enable and disable duty cycle.
- q. Display logic programming for each control sequence.
- r. **<Insert requirements>**.

9. Reporting:

- a. Generated automatically and manually.
- b. Sent to displays, printers and disc files.
- c. Types of Reporting:
 - 1) General listing of points.
 - 2) List points currently in alarm.
 - 3) List of off-line points.
 - 4) List points currently in override status.
 - 5) List of disabled points.
 - 6) List points currently locked out.
 - 7) List of items defined in a "Follow-Up" file.
 - 8) List weekly schedules.
 - 9) List holiday programming.
 - 10) List of limits and deadbands.
 - 11) **<Insert types>**.

10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

- 1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
- 2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface is to use a pointing device with pull-down or penetrating menus, color, and animation to facilitate operator understanding of system.
- 3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
- 4. Make descriptors for graphics, points, alarms, and such modifiable through operator's workstation under password control.
- 5. Make graphic displays online user definable and modifiable using the hardware and software provided.
- 6. Make data displayed within a graphic assignable regardless of physical hardware address, communication, or point type.
- 7. Make graphics online programmable and under password control.
- 8. Make points assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
- 9. Graphics to also contain software points.
- 10. Penetration within a graphic hierarchy is to display each graphic name as graphics are selected

- to facilitate operator understanding.
11. Provide a back-trace feature to permit operator to move upward in the hierarchy using a pointing device. Back trace to show all previous penetration levels. Include operator with option of showing each graphic full-screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
 12. Display operator accessed data on the monitor.
 13. Provide operator with ability to select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Display defined and linked graphic below that selection.
 14. Include operator with means to directly access graphics without going through penetration path.
 15. Make dynamic data assignable to graphics.
 16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
 17. Use color, rotation, or other highly visible means, to denote status and alarm states. Make colors variable for each class of points, as chosen by operator.
 18. Provide dynamic points with operator adjustable update rates on a per point basis from **[one]<Insert value>** second to over a **[minute]<Insert value>**.
 19. For operators with appropriate privilege, command points directly from display using pointing device.
 - a. For an analog command point such as set point, display current conditions and limits so operator can position new set point using pointing device.
 - b. For a digital command point such as valve position, show valve in current state such as open or closed so operator could select alternative position using pointing device.
 - c. Include a keyboard equivalent for those operators with that preference.
 20. Give operator ability to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot, and other information on other quadrants on screen. This feature allows real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
 21. Help Features:
 - a. Online context-sensitive help utility to facilitate operator training and understanding.
 - b. Bridge to further explanation of selected keywords and contain text and graphics to clarify system operation.
 - 1) If help feature does not have ability to bridge on keywords for more information, provide a complete set of user manuals in an indexed word-processing program, which runs concurrently with operating system software.
 - c. Available for Every Menu Item:
 - 1) Index items for each system menu item.
 22. Provide graphic generation software to allow operator ability to add, modify, or delete system graphic displays.
 - a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols[**similar to those indicated**].
 - b. Use a pointing device in conjunction with a drawing program to allow operator to perform the following:
 - 1) Define background screens.
 - 2) Define connecting lines and curves.
 - 3) Locate, orient, and size descriptive text.

- 4) Define and display colors for all elements.
- 5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
 - a. Room layouts with room identification and name.
 - b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
 - c. Location and identification of each hardware point being controlled or monitored by DDC system.
 - d. **<Insert requirements>**.
3. Control schematic for each of following, including a graphic system schematic representation[, **similar to that indicated on Drawings,**] with point identification, set point and dynamic value indication[, **sequence of operation**][and][**control logic diagram**].
4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, [**gateways**][**operator workstations**][and][**other network devices**].

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. At a minimum, include the following modification capability:
 - a. Operator Assignment: Designation of operator passwords, access levels, point segregation, and auto sign-off.
 - b. Peripheral Assignment: Assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points, and enabling and disabling of printout of operator changes.
 - c. System Configuration and Diagnostics: Communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points, and application programs and initiation of diagnostics.
 - d. System Text Addition and Change: English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time, and trouble condition.
 - e. Time and Schedule Change: Time and date set, time and occupancy schedules, exception and holiday schedules, and daylight-savings time schedules.
 - f. Point related change capability is to include the following:
 - 1) System and point enable and disable.
 - 2) Run-time enable and disable.
 - 3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
 - 4) Assignment of alarm and warning limits.

- g. Application program change capability is to include the following:
 - 1) Enable and disable of software programs.
 - 2) Programming changes.
 - 3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.
- 4. Provide software to allow operator ability to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Make additions and modifications online programmable using operator workstations, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, upload and record database on hard drive and disc for archived record.
- 5. Include high-level language programming software capability for implementation of custom DDC programs. Include a compiler, linker, and up- and down-load capability.
- 6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic, and relational operators for implementation of control sequences. Also include, at a minimum, the following:
 - a. Proportional control (P).
 - b. Proportional plus integral (PI).
 - c. Proportional plus integral plus derivative (PID).
 - d. Adaptive and intelligent self-learning control.
 - 1) Algorithm monitors loop response to output corrections and adjust loop response characteristics in accordance with time constant changes imposed.
 - 2) Algorithm operates in a continuous self-learning manner and retains in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.
- 7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.
- 8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.
- 9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.
- 10. Relational operators such as "Equal to," "Not Equal to," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.
- F. Alarm Handling Software:
 - 1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers[, **gateways**][**and other network devices**].
 - 2. Include first in, first out handling of alarms in accordance with alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
 - 3. Make alarm handling active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
 - 4. Alarms display is to include the following:
 - a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
 - b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
 - c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
 - d. Include extended message capability to allow assignment and printing of extended action messages. Capability is to be operator programmable and assignable on a per point basis.
 - 5. Direct alarms to appropriate operator workstations, printers, and individual operators by privilege

- level and segregation assignments.
 - 6. Send email alarm messages to designated operators.
 - 7. Send email, page, text, and voice messages to designated operators for critical alarms.
 - 8. Categorize and process alarms by class.
 - a. Class 1:
 - 1) Associated with fire, security, and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
 - 2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
 - 3) All conditions make an audible alarm sound and require individual acknowledgment to silence audible sound.
 - b. Class 2:
 - 1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
 - 2) Acknowledgement may be through a multiple alarm acknowledgment.
 - c. Class 3:
 - 1) General alarms; printed, displayed, and placed in unacknowledged alarm buffer queues.
 - 2) Configure so each new alarm received makes an audible alarm sound that are silenced by "acknowledging" alarm or by pressing a "silence" key.
 - 3) Make acknowledgement of queued alarms either on an individual basis or through a multiple alarm acknowledgement.
 - 4) Print alarms returning to normal condition without an audible alarm sound or require acknowledgment.
 - d. Class 4:
 - 1) Routine maintenance or other types of warning alarms.
 - 2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.
 - 9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
 - 10. To ensure that no alarm records are lost, make it possible to assign a backup printer to accept alarms in case of failure of primary printer.
- G. Reports and Logs:
- 1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
 - 2. Setup each report so data content, format, interval, and date are operator definable.
 - 3. Sample and store report data on DDC controller, within storage limits of DDC controller, and then uploaded to archive on [workstation][server] for historical reporting.
 - 4. Make it possible for operators to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
 - 5. Store reports and logs on [workstations][and][servers] hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
 - 6. Make reports and logs readily printable and set to be print either on operator command or at a

specific time each day.

- H. Standard Reports: Provide standard DDC system reports with operator ability to customize reports later.
 - 1. All I/O: With current status and values.
 - 2. Alarm: All current alarms, except those in alarm lockout.
 - 3. Disabled I/O: All I/O points that are disabled.
 - 4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
 - 5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
 - 6. Logs:
 - a. Alarm history.
 - b. System messages.
 - c. System events.
 - d. Trends.
 - e. <Insert requirement>.
- I. Custom Reports: Operator able to easily define and prepare any system data into a daily, weekly, monthly, annual, or other historical report. Reports to include a title with time and date stamp.
- J. Tenant Override Reports: Prepare Project-specific reports.
 - 1. Daily report showing total time in hours that each tenant has requested after-hours HVAC.
 - 2. Weekly report showing daily total time in hours that each tenant has requested after-hours HVAC.
 - 3. Monthly report showing daily total time in hours that each tenant has requested after-hours HVAC.
 - 4. Annual summary report that shows after-hours HVAC usage on a monthly basis.
- K. HVAC Equipment Reports: Prepare Project-specific reports.
 - 1. Chiller Report: Daily report showing operating conditions of each chiller in accordance with ASHRAE 147 including, but not limited to, the following:
 - a. Chilled-water entering temperature.
 - b. Chilled-water leaving temperature.
 - c. Chilled-water flow rate.
 - d. Chilled-water inlet and outlet pressures.
 - e. Evaporator refrigerant pressure and temperature.
 - f. Condenser refrigerant pressure and liquid temperature.
 - g. Condenser-water entering temperature.
 - h. Condenser-water leaving temperature.
 - i. Condenser-water flow rate.
 - j. Refrigerant levels.
 - k. Oil pressure and temperature.
 - l. Oil level.
 - m. Compressor refrigerant discharge temperature.
 - n. Compressor refrigerant suction temperature.
 - o. Addition of refrigerant.
 - p. Addition of oil.
 - q. Vibration levels or observation that vibration is not excessive.
 - r. Motor amperes per phase.
 - s. Motor volts per phase.
 - t. Refrigerant monitor level (PPM).
 - u. Purge exhaust time or discharge count.
 - v. Ambient temperature (dry bulb and wet bulb).
 - w. Date and time logged.

- x. <Insert requirement>.
- 2. <Insert requirements for each type of HVAC equipment requiring a report>.
- L. Utility Reports: Prepare Project-specific reports.
 - 1. Electric Report:
 - a. Include weekly report showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
 - b. Include monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each meter.
 - c. Include annual report showing monthly electrical consumption and peak electrical demand with time and date stamp for each meter.
 - d. For each weekly, monthly, and annual report, include sum total of submeters combined by load type, such as lighting, receptacles, and HVAC equipment showing daily electrical consumption and peak electrical demand.
 - e. For each weekly, monthly, and annual report, include sum total of all submeters in building showing electrical consumption and peak electrical demand.
 - 2. Natural Gas Report:
 - a. Include weekly, monthly, and annual report showing daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
 - b. For each weekly, monthly, and annual report, include sum total of submeters combined by load type, such as boilers and service water heaters showing daily natural gas consumption and peak natural gas demand.
 - c. For each weekly, monthly, and annual report, include sum total of all submeters in building showing natural gas consumption and peak natural gas demand.
 - 3. Service Water Report:
 - a. Include weekly, monthly, and annual report showing daily service water consumption and peak service water demand with time and date stamp for each meter.
 - b. For each weekly, monthly, and annual report, include sum total of submeters combined by load type, such as cooling tower makeup and irrigation showing daily service water consumption and peak service water demand.
 - c. For each weekly, monthly, and annual report, include sum total of all submeters in building showing service water consumption and peak service water demand.
 - 4. <Insert requirements for each utility requiring a report>.
- M. Energy Reports: Prepare Project-specific daily, weekly, monthly, [and annual][, annual and since-installed] energy reports.
 - 1. Prepare report for each purchased energy utility, indicating the following:
 - a. Time being reported with beginning and end date, and time indicated.
 - b. Consumption in units of measure commonly used to report specific utility consumption over time.
 - c. Gross area served by utility.
 - d. Consumption per unit area served using utility-specific unit of measure.
 - e. Cost per utility unit.
 - f. Utility cost per unit area.
 - g. Convert all utilities to a common energy consumption unit of measure and report for each

- utility.
 - h. Consumption per unit area using common unit of measure.
2. Prepare report for each renewable energy source, indicating the following:
- a. Time being reported with beginning and end date, and time indicated.
 - b. Harvested energy in units of measure commonly used to report specific harvested energy consumption over time.
 - c. Gross area served by renewable energy source.
 - d. Harvested energy per unit area served using specific unit of measure.
 - e. Cost per purchased utility unit displaced by renewable energy.
 - f. Cost savings attributed to harvested energy source.
 - g. Cost savings per unit area attributed to harvested energy.
 - h. Convert all renewable energy sources to a common energy consumption unit of measure and report for each.
 - i. Harvested energy per unit area using common unit of measure.
3. Prepare purchased energy utility report for each submetered area that indicates the following:
- a. Time being reported with beginning and end date, and time indicated.
 - b. Gross area served.
 - c. Energy consumption by energy utility type.
 - d. Energy consumption per unit area by energy utility type.
 - e. Total energy consumption of all utilities in common units of measure.
 - f. Total energy consumption of all utilities in common units of measure per unit area.
 - g. Unit energy cost by energy utility type.
 - h. Energy cost by energy utility type.
 - i. Energy cost per unit area by energy utility type.
 - j. Total cost of all energy utilities.
 - k. Total cost of all energy utilities per unit area.
4. Prepare Project total purchased energy utility report that combines all purchased energy utilities and all areas served. Project total energy report is to indicate the following:
- a. Time being reported with beginning and end date, and time indicated.
 - b. Gross area served.
 - c. Energy consumption by energy utility type.
 - d. Energy consumption per unit area by energy utility type.
 - e. Total energy consumption of all utilities in common units of measure.
 - f. Total energy consumption of all utilities in common units of measure per unit area.
 - g. Unit energy cost by energy utility type.
 - h. Energy cost by energy utility type.
 - i. Energy cost per unit area by energy utility type.
 - j. Total cost of all energy utilities.
 - k. Total cost of all energy utilities per unit area.
- N. HVAC System Efficiency Reports: Prepare Project-specific **[daily][weekly][monthly][and annual][, annual and since-installed]** HVAC system efficiency reports.
1. Prepare report for **[each]** chilled-water system, indicating the following:
- a. Time being reported with beginning and end date, and time indicated.
 - b. Cooling energy supplied during period.
 - c. Power energy consumed during period by cooling equipment used to produce cooling energy supplied. **[List power consumed for each individual piece of equipment in system and summed total of all equipment in system.]**

- d. Energy efficiency coefficient of performance determined by dividing power energy consumed into cooling energy supplied.
 - e. Energy efficiency determined by dividing cooling energy supplied into power energy consumed.
 - f. Units of measure used in report to be consistent with units indicated for system.
2. Prepare report for **[each]** heating hot-water system, indicating the following:
 - a. Time being reported with beginning and end date, and time indicated.
 - b. Heating energy supplied during period.
 - c. Fuel consumed during period by boilers used to produce heating energy supplied. **[List fuel consumed for each individual piece of equipment in system and summed total of all equipment in system.]**
 - d. Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.
 - e. Units of measure used in report are to be consistent with units indicated for system.
3. Prepare report for **[each]** steam system, indicating the following:
 - a. Time being reported with beginning and end date, and time indicated.
 - b. Heating energy supplied during period.
 - c. Fuel consumed during period by boilers used to produce heating energy supplied. **[List fuel consumed for each individual piece of equipment in system and summed total of all equipment in system.]**
 - d. Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.
 - e. Units of measure used in report are to be consistent with units indicated for system.
4. **<Insert requirements for each HVAC system requiring a report>.**

O. Weather Reports:

1. Include daily report showing the following:
 - a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
 - c. Daily minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each day calculated from a base temperature of **[55 deg F]<Insert temperature>.**
 - e. Number of cooling degree-days for each day calculated from a base temperature of **[65 deg F]<Insert temperature>.**
 - f. Daily minimum, maximum, and average outdoor carbon dioxide level.
 - g. Daily minimum, maximum, and average relative humidity.
 - h. Daily minimum, maximum, and average barometric pressure.
 - i. Daily minimum, maximum, and average wind speed and direction.
2. Include weekly report showing the following:
 - a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
 - c. Daily minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each day calculated from a base temperature of **[55 deg F]<Insert temperature>.**
 - e. Number of cooling degree-days for each day calculated from a base temperature of **[65 deg F]<Insert temperature>.**

- f. Weekly minimum, maximum, and average outdoor carbon dioxide level.
 - g. Daily minimum, maximum, and average relative humidity.
 - h. Daily minimum, maximum, and average barometric pressure.
 - i. Daily minimum, maximum, and average wind speed and direction.
 3. Include monthly report showing the following:
 - a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
 - c. Daily minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each day calculated from a base temperature of [55 deg F]<Insert temperature>.
 - e. Number of cooling degree-days for each day calculated from a base temperature of [65 deg F]<Insert temperature>.
 - f. Monthly minimum, maximum, and average outdoor carbon dioxide level.
 - g. Daily minimum, maximum, and average relative humidity.
 - h. Daily minimum, maximum, and average barometric pressure.
 - i. Daily minimum, maximum, and average wind speed and direction.
 4. Include annual (12-month) report showing the following:
 - a. Monthly minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Monthly minimum, maximum, and average outdoor wet-bulb temperature.
 - c. Monthly minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each month calculated from a base temperature of [55 deg F]<Insert temperature>.
 - e. Number of cooling degree-days for each month calculated from a base temperature of [65 deg F]<Insert temperature>.
 - f. Annual minimum, maximum, and average outdoor carbon dioxide level.
 - g. Monthly minimum, maximum, and average relative humidity.
 - h. Daily minimum, maximum, and average barometric pressure.
 - i. Daily minimum, maximum, and average wind speed and direction.
- P. Standard Trends:
1. Trend all I/O point present values, set points, and other parameters indicated for trending.
 2. Associate trends into groups, and setup a trend report for each group.
 3. Store trends within DDC controller and uploaded to hard drives automatically on reaching [75]<Insert number> percent of DDC controller buffer limit, or by operator request, or by archiving time schedule.
 4. Preset trend intervals for each I/O point after review with Owner.
 5. Make trend intervals operator selectable from 10 seconds up to 60 minutes. Make minimum number of consecutive trend values stored at one time 100 per variable.
 6. When drive storage memory is full, overwrite oldest data with most recent data.
 7. Make archived and real-time trend data available for viewing numerically and graphically by operators.
- Q. Custom Trends: Operator-definable custom trend log for any I/O point in DDC system.
1. Include each trend with interval, start time, and stop time.
 2. Sample and store data on DDC controller, within reaching [75]<Insert number> percent storage limits of DDC controller, and then uploaded to archive on [workstation][server] hard drives.
 3. Make data retrievable for use in spreadsheets and standard database programs.
- R. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming Software: **[As follows][Any of the following][One of the following]**:
 - a. Graphic Based: Use a library of function blocks made from preprogrammed code designed for DDC control systems.
 - 1) Assemble function blocks with interconnection lines that represent to control sequence in a flowchart.
 - 2) Make programming tools viewable in real time to show present values and logical results of each function block.
 - b. Menu Based: Done by entering parameters, definitions, conditions, requirements, and constraints.
 - c. Line by Line and Text Based: Programming is to declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.
4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

S. Database Management Software:

1. Where a separate SQL database is used for information storage, include database management software that separates database monitoring and managing functions by supporting multiple separate windows.
2. Secure database access using standard SQL authentication including ability to access data for use outside of DDC system applications.
3. Include database management function summarizing information on trend, alarm, event, and audit for the following database management actions:
 - a. Backup.
 - b. Purge.
 - c. Restore.
4. Database management software supporting the following:
 - a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
 - b. Maintenance: Include method of purging records from trend, alarm, event, and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
 - c. Backup: Include means to create a database backup file and select a storage location.
 - d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.
5. Information of current database activity, including the following:
 - a. Ready.
 - b. Purging record from a database.
 - c. Action failed.
 - d. Refreshing statistics.
 - e. Restoring database.

- f. Shrinking a database.
 - g. Backing up a database.
 - h. Resetting Internet information services.
 - i. Starting network device manager.
 - j. Shutting down the network device manager.
 - k. Action successful.
6. Database management software monitoring functions is to continuously read database information once operator has logged on.
7. Include operator notification through on-screen pop-up display and email message when database value has exceeded a warning or alarm limit.
8. Monitoring settings window with the following Sections:
 - a. Allow operator to set and review scan intervals and start times.
 - b. Email: Allow operator to create and review email and phone text messages to be delivered when a warning or an alarm is generated.
 - c. Warning: Allow operator to define warning limit parameters, set reminder frequency, and link email message.
 - d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency, and link email message.
 - e. Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event, and audit databases as well as operator proper security access to restore a database.
9. Monitoring settings taskbar with following informational icons:
 - a. Normal: Indicates by color and size, or other easily identifiable means, that all databases are within their limits.
 - b. Warning: Indicates by color and size, or other easily identifiable means, that one or more databases have exceeded their warning limit.
 - c. Alarm: Indicates by color and size, or other easily identifiable means, that one or more databases have exceeded their alarm limit.

2.17 ANALYTICS SOFTWARE

A. Scope: Incorporate analytics software into DDC System:

1. Licensing, without Recurring Cost: No re-occurring cost for licensing and subscriptions.
2. Licensing: With or without re-occurring cost for licensing and subscriptions.
 - a. For products with re-occurring costs, provide incremental costs broken down over a **[five][10]<Insert value>**-year operating period that begins at Substantial Completion.
 - b. Setup service agreements direct to Owner.
3. Purpose: Analyze energy and operational data to identify faults and opportunities for improved performance and reduced energy use.
4. Verification: Verify that HVAC systems and associated sequence of operations are executing as specified or as described on Drawings, through the analysis of energy and operational data, identification of faults showing where control sequences are not functioning as prescribed, and identification of opportunities for improved performance in the operation of systems.

B. Use during Project Life:

1. During Construction: Use for verification of performance during startup, commissioning, and final acceptance of DDC system.

2. During Warranty Period: Use for continuous operational tuning of DDC system and verification of operation and designed to identify warranty issues preemptively, thus reducing failures and potential down time.
3. After Warranty Period: Use to diagnose ongoing operational degradation and for Owner to perform continuous monitoring-based commissioning.

C. Minimum Features and Capabilities:

1. Operating Systems: Current version of Windows-based operating systems.
2. Time Series Database: Database technology, designed for efficient storage and analysis of large volumes of time series data, using tagging to model and describe data; supports an open-source tagging standard.
3. Data Import: Ability to accept and normalize data from a variety of sources including SQL compatible databases, CSV format files, XML format files or web services, and other EDI techniques. Once imported, software is to provide a unified data format to enable analytics algorithms to identify patterns across different data sets.
4. Open Interfaces: Open, REST-based APIs to enable integration with third-party software applications. Open APIs are to enable data to be entered/imported into database, exported from database, posting of analytic queries, and output of analytic results. APIs are to be fully documented and available as part of standard product.
5. Host: Local deployed on DDC system network.
6. Weather Data Service: Built-in worldwide weather service providing weather data including, but not limited to, the following:
 - a. Current temperature.
 - b. High temperature for the day.
 - c. Low temperature for the day.
 - d. Sunrise and sunset times.
 - e. Relative humidity.
 - f. Degree days (heating and cooling with adjustable balance point value).
 - g. Seven-day forecast.
 - h. Historical weather data extending back at least one year.
7. Email Notification: Automatic notification of detected issues via email including, but not limited to, the following:
 - a. Immediate notification of detected issues.
 - b. Daily digest or summary of detected issues.
 - c. Ability to delineate which notifications are sent to which recipients down to the level of specifying individual issues sent to individual recipients.

D. Hardware Requirements:

1. Host on a server in a virtual environment complying with Owner's security requirements.
2. Comply with standard software and hardware profiles required by Owner.

E. Analytic Rules:

1. Custom Rule Development: Develop customized rules and algorithms tailored to operational needs and characteristics of individual facilities and needs of monitoring and verification project and fault-detection requirements of Project without depending on manufacturer for rule development. Provide tools for user development and full documentation.
2. Standard Analytic Functions: Library of standard analytic functions is to use these standard analytic functions as elements to build custom analytic rules for specific needs of individual facilities.

3. Existing library of not less than 200 standard analytic rules written for applications similar to those required for this Project.

F. Reporting:

1. Standard Views of Analytic Results: Standard views to present analytic results, automatically generated when issues are found by analytic rules including, but not limited to, the following:
 - a. Rules violations across a portfolio of sites, rules violations per site, including time, date, and duration of all violations.
 - b. Ability to assign cost relationships to rule logic to provide cost per violation.
 - c. Standard filters to enable operator to easily look at rule violations by site, data, and violation type for any selected date or date range.
 - d. Automatic calculation and presentation of Key Performance Indicators (KPIs) and to define custom KPIs as needed.
2. Custom Views of Analytic Results:
 - a. Any standard system view is to be able to be saved as a custom report including its configuration criteria, e.g., time range, sites, rule violations, or other configuration options as applicable to standard system view.
 - b. Created by making queries against the database and saving the query as a saved report executed by single mouse click.
 - c. Export: Support report views export into CSV, Excel, XML, and HTML format, accomplished in a couple of mouse clicks.

G. Energy-Specific Reporting and Information Presentation Tools:

1. Greenhouse Gas Analysis: Energy/carbon dioxide relationships; easily changed and added without involvement of software manufacturer.
2. Energy Baseline: Quantify and define energy consumption and demand baselines (including weather normalization metrics) and compare actual and forecasted energy demand and consumption against those baselines.
3. Benchmarking: Multisite benchmarking to compare energy consumption and demand profiles and baselines across all buildings within Owner's portfolio.
4. Forecasting: Forecast near-future loads by using historic trends and forecasted weather data.
5. Financial Analysis: Calculate costs based on energy consumption and demand and energy costs and associate costs with any faults discovered by any analytic function and perform model- or tariff-based calculations to determine costs.
6. Tracking of Key Performance Indicators: Definition and tracking of user-defined key performance indicators/operational metrics. Examples include energy demand and consumption normalized for area and weather, peak demand, and consumption shown with minimum and maximum ranges across any user-selectable period.
7. Correlation of Energy Use with Equipment Operation: Automatically present views showing correlation between energy demand and consumption and operation of loads associated with that usage. Include the following:
 - a. All submeters and virtual meters.
 - b. Weather data as a selectable item.

H. Implementation:

1. Apply analytic rules to all HVAC systems and equipment monitored and controlled by DDC system. To extent available, use a subset of rules in existing rules library.
2. Implement rules to aid in determining proper operation of any HVAC system with a programmed sequence of operation.

3. Generate reports to aid in verification of proper operation during initial system startup and commissioning to supplement (not replace) commissioning agent reports.
4. Prepare quarterly reports summarizing faults detected and KPIs, including recommended corrective action.

I. Training:

1. Train Owner sufficiently to use software without need for external support.

2.18 MAINTENANCE MANAGEMENT SOFTWARE

A. Scope:

1. Include complete and functional software-driven maintenance management system to perform scheduling of preventive maintenance and generation of work orders, for mechanical and electrical equipment and systems, and other equipment and systems indicated.
2. Automatically generate work orders from alarm conditions, run time, and calendar time. For each work order generated, list parts, tools, and craftspeople and define task to be performed.
3. Use work orders generated to schedule a repair or preventive maintenance routine.
4. Use work orders to track completion of work, parts used, and total cost of repair.
5. Include a database inventory tracking system to automatically update inventory database to show quantity of tools, repair parts, and expendables used for a work order.
6. Print work orders and preventive maintenance schedules[**on a printer assigned solely to maintenance management function**].

B. Additional Hardware Requirements:

1. Maintenance management software is to not require additional hardware[, **except for an additional printer that is dedicated to maintenance management**].

C. Integration: Integrate maintenance management software into DDC system.

D. Software Requirements:

1. From main menu of maintenance management system, use selection of icons to penetrate to individual functions described below.
2. Work Orders:
 - a. Automatically generate work orders initiated from alarm conditions, accumulated run time, or calendar time. Work orders generated are to specify a particular task to be accomplished including labor, material, and tools needed to accomplish work.
 - b. Include at least two of the following types of work orders:
 - 1) Corrective and Emergency Maintenance: Generate for a specific job or repair for emergency, breakdown, or scheduled work.
 - 2) Preventive Maintenance: Use on a periodic basis to generate preventive maintenance work orders.
 - c. Include the following functions:
 - 1) Work Order Tracking: Perform every function related to processing work orders including creating, approving and initiating work orders, checking their status history, and closing or reworking them when appropriate.
 - 2) Work Requests: Report any problems that require corrective maintenance activity

- generated by dispatchers and those people designated to request work orders.
- 3) Quick Reporting: Report work done on an open work order or a small job.
- 4) Work Manager: Specify type of labor to be applied to a specific work order at specific times. Include capability to dispatch one or more laborers to top-priority jobs on as-needed basis and to interrupt work in progress to reassign labor to higher priority tasks.

d. Reports:

- 1) Daily Maintenance Schedule by Supervisor: List a schedule of open work orders for a specified date by supervisor.
- 2) Equipment Cost Roll-up Report: Include a roll-up of equipment costs incurred since the date the report was last run.
- 3) Delinquent Work Order Report: List open work orders whose target completion date is earlier than the date the report is run.
- 4) Employee Job Assignments: List labor codes that have job assignments for specified date.
- 5) Daily Work Order Assignment: List work orders that have labor assignments for specified date.
- 6) Estimated versus Actual Work Order Costs: List a cost summary of outstanding work orders.
- 7) Open Work Orders Report: List open work orders for locations and equipment.

3. Inventory:

- a. Include an inventory tracking system to keep track of stocked, non-stocked, and special-order items.
- b. Link inventory tracking to database and when items are consumed, as noted on a work order issued by system, and automatically update inventory of stocked items.
- c. Include the following functions:
 - 1) Inventory Control: Enter, display, and update information on each inventory item. Allow viewing of master inventory records that are independent of storeroom locations or item/location records. Include a screen that lists inventory transactions that move items in or out of inventory or from one storeroom location to another. Minimum information tracked is to include the following:
 - a) Vendors supply items.
 - b) Item balances, including the bin and lot level for each storeroom location.
 - c) Alternative items.
 - 2) Issues and Transfers: Issue stock directly from inventory, with or without a work order. When transfer of stock from one location to another location occurs, provide appropriate adjustments in stock balance record. Include a trace record of stock transfers from one storeroom to another.
 - 3) Item Assembly Structures: Include modeling of equipment with inventory items and building of equipment and location hierarchies.
 - 4) Metered Material Usage:
 - a) Track usage by a piece of equipment.
 - b) Record against a standing work order for a selected piece of equipment.
 - c) Include a material usage transaction for each item of material used and provide as an input to calculation for per unit material consumption report for a piece of equipment.

d. Reports:

- 1) Inventory Analysis Report: List for a given storeroom location, inventory items analysis information that allows quick identification of which inventory items represent greatest monetary investment for dollar value and rate of turnover.
 - 2) Inventory Cycle Count Report: List for a specified storeroom, inventory items that are due to be cycle-counted, based on cycle-count frequency and last count date.
 - 3) Economic Order Quantity Report: For a given storeroom location, display optimum economic ordering quantity for items in selected results set.
 - 4) Inventory Pick Report: A pick list, by work order for items needed to be pulled from a designated storeroom's inventory for work orders having a target start date of specified date.
 - 5) Suggested Order Report: List inventory items in selected results set that are due to be recorded, for a specified storeroom location, based on the following calculation: Suggest a reorder if current balance minus reserve quantity plus on-order quantity is less than reorder point.
 - 6) Reorder Point Report: List selected set of items and optimum minimum level to have in stock based on demand, lead delivery time, and a reserve safety stock.
 - 7) Inventory Valuation Report: Gives an accounting of cost of current inventory, for inventory records in a designated storeroom location.
 - 8) Item Order Status: Lists items on order.
 - 9) List of Expired Items: Lists expired lot items in a storeroom. Report is to include item number, description, expiration date, bin number, lot number, manufacturer lot number, and quantity of expired items in that lot and bin.
 - 10) Item Availability at All Locations: Lists alternative storeroom locations for selected items.
 - 11) Where Used Report: List equipment on which item is recorded as being used.
4. Equipment:
- a. Include equipment and location records; establish relationships between equipment, between locations, and between equipment and locations; track maintenance costs; and enter and review meter readings.
 - b. Include the following functions:
 - 1) Equipment: Store equipment numbers and corresponding information including equipment class, location, vendor, up/down status, and maintenance costs for each piece of equipment. Include building of equipment assemblies. Provide equipment assemblies hierarchical ordering for arrangement of buildings, departments, equipment, and sub-assemblies.
 - 2) Operating Locations: Facilitate creation of records for operating locations of equipment, and track equipment that is used in multiple locations. In addition, allow hierarchical organization of equipment operating in facility by means of grouping equipment locations into areas of responsibility.
 - 3) Failure Codes: Develop and display failure hierarchies to acquire an accurate history of types of failures that affect equipment and operating locations.
 - 4) Condition Monitoring: Display time-related or limit measurements recorded for a piece of equipment. Generate work orders from this screen and to take immediate action on problem conditions.
 - c. Reports:
 - 1) Availability Statistic by Location: List equipment availability by location over a user-specified period.
 - 2) Equipment Failure Summary: List total number of failures by problem code for a piece of equipment for specified period.
 - 3) Detailed Equipment Failure Report by Equipment: List of failure reports for the

- current piece of equipment for specified period.
- 4) Equipment Hierarchy Report: List of equipment.
- 5) Equipment History Graphs: Include a graphical report in histogram format that displays equipment breakdown history over a specified period.
- 6) Equipment Measurement Report: Tabular listing and description of each measurement point for a piece of equipment and history of measurements taken for that point.
- 7) Maintenance Cost by Equipment: List of transactions costs for elected equipment in the specified date range.
- 8) Failure Count by Equipment: Graphically report number of failures for each piece of equipment showing number of failures for each piece of equipment over a specified period, occurrence of each problem code within set of failures, and failures by problem code.
- 9) Failure Analysis Graphs: Graphically report number of failures for each piece of equipment over a specified period, number of occurrences of each problem code within set of failures, and failures by problem code.
- 10) Failure Code Hierarchy Report: List of failure codes in each level of failure hierarchy.
- 11) Location Failure Summary: A summary for each selected location of failures reported and any hierarchy level locations for specified period.
- 12) Failure Summary by Location: A summary of failures for selected location and their subordinate locations that are part of hierarchical system.
- 13) Detailed Failure Report by Location: List all failures for selected location and its subordinate locations that are part of hierarchical system.
- 14) Maintenance Cost by System: List of total costs reported in a given date range for locations in selected hierarchical system.
- 15) Location Hierarchy Report: Lists member locations of hierarchical system displayed in hierarchical fashion.

5. Purchasing:

- a. Include preparation and generation of purchase requisitions and purchase orders; to report receipt of both items and services, match invoices with purchase orders and receipts and define and convert foreign currencies.
- b. Include the following functions:
 - 1) Purchase Requisition: Create and process purchase requisitions for items and services.
 - 2) Purchase Orders: Create and process purchase orders for items and services from scratch or from purchase requisitions. Record receipts of items and services.
 - 3) Invoices: Include functionality to match purchase orders with invoices and receipts. It is also possible to match a service receipt to an invoice. Project for entering of an invoice for bills that do not require purchase orders or receipts.
 - 4) Currency Management: Define currencies and specify exchange rates. Include preparation of purchase requisitions and purchase orders in currency of vendor while tracking costs in systems base currency.
- c. Reports:
 - 1) Invoice Approval Report: Include an approval form for entered invoices.
 - 2) Inventory Receipts Register: List purchase orders and inventory received for user-specified time frame.
 - 3) Direct Purchase Back-Order Report: List of items ordered as a direct purchase not received by required delivery date.
 - 4) Standard Purchase Order: A printing of primary purchase order with vendors shipping information, and items purchased.
 - 5) Purchase Order Status Report: List of purchase orders whose status has changed

- 6) during a certain period.
- 6) Standard Purchase Requisition: A printing of primary purchase requisition, including vendor name and shipping information.
- 6. Job Plans:
 - a. Include creation of a detailed description of work to be performed by work order. Job plan is to contain operations, procedures and list of estimated material, labor, and tools required for work.
- 7. Labor:
 - a. Store information on employees, contractors, and crafts and include the following functions:
 - 1) Labor: Create, modify, and view employee records. Employee records are to contain pay rate, overtime worked, overtime refused, special skills, and certifications.
 - 2) Crafts: Create, modify, and view craftspeople records.
 - 3) Labor Reporting: Report labor usage by employee or craft externally from work orders module.
 - b. Reports:
 - 1) Employee Attendance Analysis: List of planned attendance, actual attendance, and vacation and sick time in hours as a percentage of planned attendance for selected employees for specified period.
 - 2) Labor Productivity Analysis: List of actual labor hours by labor report category showing each by percentage.
 - 3) Labor Availability versus Commitments by Crafts: A graphical report that details available labor hours versus committed work order hours by craft and day.
- 8. Calendars:
 - a. Establish calendar records indicating working time for equipment, location, craft, and labor records.
- 9. Resources:
 - a. Include entry and retrieval of data associated with resources required to maintain facility and to include the following functions:
 - 1) Companies: Establish and update data on vendors and other companies.
 - 2) Tools: Create and maintain information on the tools used on jobs. Make information contained within this module available to job plans and work orders.
 - 3) Service Contracts: Specify information on service contracts with vendors or manufacturers.
- 10. Custom Applications:
 - a. Include creation of customized database tables and application screens that supplement functions specified.
- 11. Setup:



- a. Include configuration of database, security, and setup applications.
- b. Perform the following functions:
 - 1) Reports and Other Applications: Register reports and other applications for use within system.
 - 2) Documents: Enter, track, and link information from Drawings to equipment and inventory items.
 - 3) Chart of Accounts: Add or modify accounts; set up financial periods; enter inventory accounts, company accounts, and resource recovery accounts; and define tax codes and rates.
 - 4) Signature Security: Establish each user's access rights to modules, applications, screens, and options.
 - 5) Database Configuration: Customize database, including adjusting field lengths and modifying data types.
 - 6) Application Setup: Change position of icons and menu items on the main menu screen.
 - 7) Application Launching: Allow for connecting of third-party applications to data fields and push buttons.

12. Utilities:

- a. Include utilities module that allows system administrator to customize system and to maintain database.
- b. Include the following functions:
 - 1) Interactive SQL: Include access to database for database management functions of import/export and backup.
 - 2) Edit Windows: Display a dialog box to customize an application.
 - 3) Archive Data: Remove records from database and store them for future reference.

E. Documentation:

- 1. Include complete documentation for system consisting of a User Manual and Systems Administrator Guide.
- 2. Describe how to use each application module and screen with step-by-step instructions detailing entry and retrieval of data for functions specified.
- 3. Include a step-by-step description of how each report is defined and retrieved.
- 4. Bind documentation and clearly title it indicating volume number and use.

2.19 OFFICE APPLICATION SOFTWARE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[Microsoft Corporation]**
 - 2. **<Insert manufacturer's name>**
- B. Include current version of office application software at time of Substantial Completion.
- C. Office application software package to include multiple separate applications and use a common platform for all applications.
 - 1. Database.
 - 2. Email.

3. Presentation.
4. Publishing.
5. Spreadsheet.
6. Word processing.
7. **<Insert application>.**

2.20 ASHRAE 135 GATEWAYS

- A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, **<Insert equipment,>** and variable-speed drives.
- B. Include gateways to connect BACnet to legacy systems where indicated, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment.
- C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.
- D. Gateway Minimum Requirements:
 1. Read and view all readable object properties on non-BACnet network to BACnet network, and vice versa, where applicable.
 2. Write to all writable object properties on non-BACnet network from BACnet network, and vice versa, where applicable.
 3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet, and vice versa.
 4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs in accordance with ASHRAE 135.
 5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
 6. Backup programming and parameters on CD media with ability to modify, download, backup, and restore gateway configuration.

2.21 ASHRAE 135 PROTOCOL ANALYZER

- A. Analyzer and required cables and fittings for connection to ASHRAE 135 network.
- B. Include the following minimum capabilities:
 1. Capture and store to a file data traffic on all network levels.
 2. Measure bandwidth usage.
 3. Filtering options with ability to ignore select traffic.

2.22 CTA-709.1-D NETWORK HARDWARE

- A. Routers:
 1. Network routers, including routers configured as repeaters, are to comply with requirements of CTA-709.1-D and include connection between two or more CTA-709.3 TP/FT-10 channels or

- between two or more CTA-709.3 TP/FT-10 channels and a TP/XF-1250 channel.
2. IP Routers:
 - a. Perform layer three routing of CTA-709.1-D packets over an IP network in accordance with CTA-852-C.
 - b. Include appropriate connection to IP network and connections to CTA-709.3 TP/FT-10 or TP/XF-1250 network.
 - c. Support the Dynamic Host Configuration Protocol for IP configuration and use of an CTA-852-C Configuration Server (for CTA-852-C configuration), but do not rely on these services for configuration.
 - d. Capable of manual configuration via a console RS-232 port.
 - B. Gateways:
 1. Perform bidirectional protocol translation from one non-CTA-709.1-D protocol to CTA-709.1-D.
 2. Incorporate a network connection to TP/FT-10 network in accordance with CTA-709.3 and a connection for non-CTA-709.1-D network.

2.23 WIRELESS ROUTERS FOR OPERATOR INTERFACE

- A. Dual-Band Wireless Routers:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ASUSTek Computer Inc.]**
 - b. **[Cisco Linksys]**
 - c. **[D-Link Corporation/D-Link Systems, Inc.]**
 - d. **[NETGEAR Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Description: High-speed, dual-band router with integral Ethernet ports and USB port.
 3. Technology: IEEE 802.11; 2.4 and 5 GHz speed bands.
 4. Wireless Speed: Up to **[300]<Insert number>** Mbps on 2.4 GHz band and up to **[2400]<Insert number>** Mbps on 5 GHz band.
 5. Compatibility: IEEE 802.11 ac wireless devices.
 6. Ethernet Ports: Four, gigabit (1000 Mbps).
 7. USB Port: One, USB 2.0 or 3.0.
 8. Wireless Security: Wi-Fi Protected Access (WPA) and WPA2 in accordance with IEEE 802.11.
- B. Tri-Band Wireless Routers:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ASUSTek Computer Inc.]**
 - b. **[Cisco Linksys]**
 - c. **[NETGEAR Inc.]**
 - d. **<Insert manufacturer's name>**
 2. Description: High-speed, tri-band router with integral Ethernet ports and USB port.

3. Technology: IEEE 802.11; 2.4 and 5 GHz speed bands.
4. Wireless Speed: Up to [600]<Insert number> Mbps on 2.4 GHz band and up to [4800]<Insert number> Mbps on two 5 GHz bands.
5. Compatibility: IEEE 802.11 [ac][or][ax] wireless devices.
6. Ethernet Ports: [Four]<Insert number>, gigabit [1000][2500]<Insert number> Mbps.
7. USB Port: One, USB 2.0 or 3.0.
8. Wireless Security: Wi-Fi Protected Access (WPA) and WPA2 in accordance with IEEE 802.11.

2.24 DDC CONTROLLERS

- A. DDC system consisting of a combination of network controllers, programmable application controllers, and application-specific controllers to satisfy performance requirements indicated.
- B. DDC controllers to perform monitoring, control, energy optimization, and other requirements indicated.
- C. DDC controllers are to use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
- D. Each DDC controller is capable of full and complete operation as a completely independent unit and as a part of DDC system wide distributed network.
- E. Environment Requirements:
 1. Controller hardware suitable for anticipated ambient conditions.
 2. Controllers located in conditioned space rated for operation at [32 to 120 deg F]<Insert temperature range>.
 3. Controllers located outdoors rated for operation at [40 to 150 deg F]<Insert temperature range>.
- F. Power and Noise Immunity:
 1. Operate controller at 90 to 110 percent of nominal voltage rating and perform an orderly shutdown below 80 percent of nominal voltage.
 2. Protect against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.
- G. DDC Controller Spare Processing Capacity:
 1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
 - a. Network Controllers: [50][60][70]<Insert number> percent.
 - b. Programmable Application Controllers: Not less than [60][70][80]<Insert number> percent.
 - c. Application-Specific Controllers: Not less than [70][80][90]<Insert number> percent.
 2. Memory for DDC controller's operating system and database are to include the following:
 - a. Monitoring and control.
 - b. Energy management, operation, and optimization applications.
 - c. Alarm management.
 - d. Historical trend data of all connected I/O points.
 - e. Maintenance applications.
 - f. Operator interfaces.
 - g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:

- a. **[10][20]<Insert number>** percent of each AI, AO, BI, and BO point connected to controller.
- b. Minimum Spare I/O Points per Controller:
 - 1) AIs: **[Two][Three]<Insert number>**.
 - 2) AOs: **[Two][Three]<Insert number>**.
 - 3) BIs: **[Three][Five]<Insert number>**.
 - 4) BOs: **[Three][Five]<Insert number>**.
 - 5) Option to provide universal I/O to meet spare requirements.

2. Programmable Application Controllers:

- a. **[10][20]<Insert number>** percent of each AI, AO, BI, and BO point connected to controller.
- b. Minimum Spare I/O Points per Controller:
 - 1) AIs: **[Two][Three]<Insert number>**.
 - 2) AOs: **[Two][Three]<Insert number>**.
 - 3) BIs: **[Three][Five]<Insert number>**.
 - 4) BOs: **[Three][Five]<Insert number>**.
 - 5) Option to provide universal I/O to meet spare requirements.

3. Application-Specific Controllers:

- a. **[10]<Insert number>** percent of each AI, AO, BI, and BO point connected to controller.
- b. Minimum Spare I/O Points per Controller:
 - 1) AIs: **[One][Two]<Insert number>**.
 - 2) AOs: **[One][Two]<Insert number>**.
 - 3) BIs: **[One][Two]<Insert number>**.
 - 4) BOs: **[One][Two]<Insert number>**.
 - 5) Option to provide universal I/O to meet spare requirements.

I. Maintenance and Support: Include the following features to facilitate maintenance and support:

- 1. Mount microprocessor components on circuit cards for ease of removal and replacement.
- 2. Means to quickly and easily disconnect controller from network.
- 3. Means to quickly and easily access connect to field test equipment.
- 4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. General Requirements for CTA-709.1-D DDC Controllers:

- 1. LonMark certified.
- 2. Distinguishable and accessible switch, button, or pin, when pressed is to broadcast its 48-bit Node ID and Program ID over network.
- 3. TP/FT-10 transceiver in accordance with CTA-709.3 and connections for TP/FT-10 control network wiring.
- 4. TP/XF-1250 transceiver in accordance with CTA-709.3 and connections for TP/XF-1250 control network wiring.
- 5. Communicate using CTA-709.1-D protocol.
- 6. Controllers configured into subnets, as required, to comply with performance requirements indicated.
- 7. Network communication through LNS network management and database standard for CTA-

709.1-D network devices.

8. Locally powered, not powered through network connection.
9. Functionality required to support applications indicated including, but not limited to, the following:
 - a. I/Os indicated and as required to support sequence of operation and application in which it is used. SNVTs to have meaningful names identifying the value represented by SNVT. Unless SNVT of an appropriate engineering type is unavailable, all network variables to be of SNVT with engineering units appropriate to value the variable represents.
 - b. Configurable through SCPTs defined in LonMark SCPT List, operator-defined UCPTs, network configuration inputs (NCIs) of SNVT type defined in LonMark SNVT List, NCIs of an operator-defined network variable type, or hardware settings on controller itself for all settings and parameters used by application in which it is used.
10. Programmable controllers comply with "LonMark Interoperability Guidelines" and have LonMark certification.

K. I/O Point Interface:

1. Connect hardwired I/O points to network, programmable application, and application-specific controllers.
2. Protect I/O points so shorting of point to itself, to another point, or to ground will not damage controller.
3. Protect I/O points from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:
 - a. Include monitoring of low-voltage (0 to 10 V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
 - b. Compatible with, and field configurable to, sensor and transmitters installed.
 - c. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of [8][12]<Insert value> bits or better to comply with accuracy requirements indicated.
 - d. Signal conditioning including transient rejection for each AI.
 - e. Capable of being individually calibrated for zero and span.
 - f. Incorporate common-mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
 - g. External conversion resistors are not permitted.
5. AOs:
 - a. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of [8][12]<Insert value> bits or better to comply with accuracy requirements indicated.
 - b. Output signals range of [4 to 20 mA dc][or][0 to 10 V dc] as required to include proper control of output device.
 - c. Capable of being individually calibrated for zero and span.
 - d. Drift is to be not greater than 0.4 percent of range per year.
 - e. External conversion resistors are not permitted.
6. BIs:
 - a. Accept contact closures and ignore transients of less than 5 ms duration.
 - b. Isolate and protect against an applied steady-state voltage of up to 180 V ac peak.
 - c. Include a wetting current of at least 12 mA to be compatible with commonly available control devices and protected against effects of contact bounce and noise.
 - d. Sense "dry contact" closure without external power (other than that provided by controller)

- being applied.
- e. Pulse accumulation input points complying with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Include buffer to totalize pulses. Pulse accumulator is to accept rates of at least 20 pulses per second. Reset the totalized value to zero on operator's command.

7. BOs:

- a. Include relay contact closures or triac outputs for momentary and maintained operation of output devices.
 - 1) Relay contact closures to have a minimum duration of 0.1 second and at least 180 V of isolation.
 - 2) Include electromagnetic interference suppression on all output lines to limit transients to non-damaging levels.
 - 3) Minimum contact rating to be 1 A at 24 V ac.
 - 4) Triac outputs to have at least 180 V of isolation and minimum contact rating of 1 A at 24 V ac.
- b. Include BOs with two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
- c. BOs to be selectable for either normally open or normally closed operation.
- d. Include tristate outputs (two coordinated BOs) for control of three-point, floating-type electronic actuators without feedback.
- e. Limit use of three-point floating devices to VAV terminal unit control applications[, **and other applications indicated on Drawings,**]**<Insert applications>**. Control algorithms to operate actuator to one end of its stroke once every **[12][24]<Insert time>** hours for verification of operator tracking.

2.25 NETWORK CONTROLLERS

A. General:

- 1. Include adequate number of controllers to achieve performance indicated.
- 2. Provide one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
- 3. Include enough memory to support its operating system, database, and programming requirements with spare memory indicated.
- 4. Share data between networked controllers and other network devices.
- 5. Operating system of controller to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
- 6. Include network controllers with a real-time clock.
- 7. Controller to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller is to assume a predetermined failure mode and generate an alarm notification.
- 8. Make controllers fully programmable.

B. Communication:

- 1. Network controllers communicate with other devices on DDC system **[Level 1]<Insert level>** network.
- 2. Network controller to also perform routing if connected to network of programmable application controllers and application-specific controllers.

C. Operator Interface:

1. Equip controllers with a service communications port for connection to **[desktop operator's workstation][portable operator's workstation][POT][or][mobile device]**.
2. Local Keypad and Display:
 - a. Equip controller with local keypad and digital display for interrogating and editing data.
 - b. Use of keypad and display requires a security password.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain Basic Input Output System (BIOS) and programming information in event of power loss for at least **[72][96]<Insert number>** hours.

2.26 PROGRAMMABLE APPLICATION CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide enough memory to support its operating system, database, and programming requirements with spare memory indicated.
3. Share data between networked controllers and other network devices.
4. Include controller with operating system to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Include controllers **[that perform scheduling]** with a real-time clock.
6. Controller is to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller assumes a predetermined failure mode and generates an alarm notification.
7. Fully programmable.

B. Communication:

1. Programmable application controllers are to communicate with other devices on network.

C. Operator Interface:

1. Equip controllers with a service communications port for connection to **[desktop operator's workstation][portable operator's workstation][POT][or][mobile device]**.
2. Local Keypad and Display:
 - a. Equip controller with local keypad and digital display for interrogating and editing data.
 - b. Protect use of keypad and display by security password.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain BIOS and programming information in event of power loss for at least 72 hours.

2.27 APPLICATION-SPECIFIC CONTROLLERS

- A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment or system. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.
 - 1. Capable of standalone operation and continued control functions without being connected to network.
 - 2. Share data between networked controllers and other network devices.
- B. Communication: Application-specific controllers are to communicate with other application-specific controllers and devices on network, and to programmable application controllers and network controllers.
- C. Operator Interface: Equip controllers with a service communications port for connection to **[desktop workstation][portable operator's workstation][POT][or][mobile device]. [Connection is to extend to port on space temperature sensor that is connected to controller.]**
- D. Serviceability:
 - 1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
 - 2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
 - 3. Use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.28 CONTROLLER SOFTWARE

- A. General:
 - 1. Software applications are to reside and operate in controllers. Edit applications through operator workstations[**or mobile devices**].
 - 2. Identify I/O points by up to **[30]<Insert number>**-character point name and up to **[16]<Insert number>**-character point descriptor. Use same names throughout, including at operator workstations.
 - 3. Execute control functions within controllers using DDC algorithms.
 - 4. Configure controllers to use stored default values to ensure fail-safe operation. Use default values when there is a failure of a connected input instrument or loss of communication of a global point value.
- B. Security:
 - 1. Secure operator access using individual security passwords and user names.
 - 2. Passwords restrict operator to points, applications, and system functions as assigned by system manager.
 - 3. Record operator log-on and log-off attempts.
 - 4. Protect from unauthorized use by automatically logging off after last keystroke. Make the delay time operator-definable.
- C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule is to consist of the following:
 - 1. Weekly Schedules:

- a. Include separate schedules for each day of week.
 - b. Each schedule should include capability for start, stop, optimal start, optimal stop, and night economizer.
 - c. Each schedule may consist of up to 10 events.
 - d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.
 2. Exception Schedules:
 - a. Include ability for operator to designate any day of the year as an exception schedule.
 - b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.
 3. Holiday Schedules:
 - a. Include capability for operator to define up to 99 special or holiday schedules.
 - b. Place schedules on scheduling calendar with ability to repeated each year.
 - c. Operator able to define length of each holiday period.
- D. System Coordination:
1. Include standard application for proper coordination of equipment.
 2. Include operator with a method of grouping together equipment based on function and location.
 3. Include groups that may be for use in scheduling and other applications.
- E. Binary Alarms:
1. Set each binary point to alarm based on operator-specified state.
 2. Include capability to automatically and manually disable alarming.
- F. Analog Alarms:
1. Provide each analog object with both high and low alarm limits.
 2. Include capability to automatically and manually disable alarming.
- G. Alarm Reporting:
1. Include ability for operators to determine action to be taken in event of an alarm.
 2. Route alarms to appropriate operator workstations based on time and other conditions.
 3. Include ability for alarms to start programs, print, be logged in event logs, generate custom messages, and display graphics.
- H. Remote Communication:
1. Include ability for system to notify operators by phone message, text message, and email in event of an alarm.
- I. Electric Power Demand Limiting:
1. Monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.
 2. Predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded,

- action will be taken to restore loads in a predetermined manner.
3. Accomplish demand reduction by the following means:
 - a. Reset air-handling-unit supply temperature set points.
 - b. Reset space temperature set points.
 - c. De-energize equipment based on priority.
 4. Base demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables on the means by which electric power service provider computes demand charges.
 5. Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.
 6. Include means operator to make the following changes online:
 - a. Addition and deletion of loads controlled.
 - b. Changes in demand intervals.
 - c. Changes in demand limit for meter(s).
 - d. Maximum shutoff time for equipment.
 - e. Minimum shutoff time for equipment.
 - f. Select rotational or sequential shedding and restoring.
 - g. Shed and restore priority.
 7. Include the following information and reports, to be available on an hourly, daily, weekly, monthly, and annual basis:
 - a. Total electric consumption.
 - b. Peak demand.
 - c. Date and time of peak demand.
 - d. Daily peak demand.
- J. Maintenance Management: Monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.
- K. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.
- L. Control Loops:
1. Support any of the following control loops, as applicable to control required:
 - a. Two-position (on/off, open/close, slow/fast) control.
 - b. Proportional control.
 - c. Proportional plus integral (PI) control.
 - d. Proportional plus integral plus derivative (PID) control.
 - 1) Include PID algorithms with direct or reverse action and anti-windup.
 - 2) Algorithm to calculate a time-varying analog value used to position an output or stage a series of outputs.
 - 3) Make controlled variable, set point, and PID gains operator-selectable.
 - e. Adaptive (automatic tuning).
- M. Staggered Start: Prevent all controlled equipment from simultaneously restarting after a power outage. Make the order which equipment (or groups of equipment) is started, along with the time delay between starts, operator-selectable.
- N. Energy Calculations:

1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
2. Include algorithm that calculates a sliding-window average (rolling average). Make algorithm flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
3. Include algorithm that calculates a fixed-window average. Use a digital input signal to define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

O. Anti-Short Cycling:

1. Protect BO points from short cycling.
2. Feature to allow minimum on-time and off-time to be selected.

P. On and Off Control with Differential:

1. Include algorithm that allows BO to be cycled based on a controlled variable and set point.
2. Use direct- or reverse-acting algorithm and incorporate an adjustable differential.

Q. Run-Time Totalization:

1. Include software to totalize run-times for all BI **[and BO]**points.
2. Assign a high run-time alarm, if required, by operator.

2.29 ENCLOSURES

A. General:

1. House each controller and associated control accessories in **[single]**enclosure. Enclosure is to serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies, and transformers.
2. Do not house more than one controller in single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
5. Individual, wall-mounted, single-door enclosures maximum of **[36 inches]<Insert dimension>** wide and **[48 inches][60 inches]<Insert dimension>** high.
6. Individual, wall-mounted, double-door enclosures maximum of **[60 inches]<Insert dimension>** wide and **[36 inches]<Insert dimension>** high.
7. Freestanding enclosures maximum of **[48 inches]<Insert dimension>** wide and **[72 inches]<Insert dimension>** high.
8. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
9. Supply each enclosure with complete set of as-built schematics, tubing, and wiring diagrams and product literature located in pocket on inside of door. **[For enclosures with windows, include pocket on bottom of enclosure.]**

B. Internal Arrangement:

1. Arrange internal layout of enclosure to group and protect **[pneumatic,]**electric, and electronic components associated with controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling, and wiring complying with requirements and

standards indicated.

5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than [10][20]<Insert number> percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install maximum of two wires on each side of terminal.
9. Include enclosure field electric power supply with toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with line-voltage nominal 20 A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with 5 A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with **[engraved, laminated phenolic]**nameplates (black letters on a white background). Nameplates are to have at least **1/4-inch**- high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with continuous removable cover.
14. Label each end of cable, wire, and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least [15][25]<Insert number> percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction, and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

D. Wall-Mounted, NEMA 250, Type 1:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - b. **[Hammond Mfg. Co. Inc]**
 - c. **[Hoffman; brand of nVent Electrical plc]**
 - d. **[Saginaw Control and Engineering]**
 - e. **<Insert manufacturer's name>**
2. NRTL listed in accordance with UL 50 or UL 50E.
3. Construct enclosure of steel, not less than the following:

- a. Enclosure Size Less Than 24 Inches (600 mm): **[0.053 inch][or][0.067 inch]** thick.
 - b. Enclosure Size 24 Inches (600 mm) and Larger: **[0.067 inch][or][0.093 inch]** thick.
4. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior Color: **[White][Gray][Selected by Architect][Manufacturer's standard]<Insert color>**.
 - b. Interior Color: **[White][Gray][Manufacturer's standard]**.
5. Hinged door full size of front face of enclosure and supported using the following:
 - a. Enclosures Sizes Less Than 36 Inches (900 mm) Tall: Multiple butt hinges.
 - b. Enclosures Sizes 36 Inches (900 mm) Tall and Larger: Continuous piano hinges.
6. Removable internal panel with **[white][or][gray]** polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Size Less Than 24 Inches (600 mm): **[Solid][or][perforated]** steel, **0.053 inch** thick.
 - b. Size 24 Inches (600 mm) and Larger: Solid **[aluminum, 0.10 inch][or][steel, 0.093 inch]** thick.
7. Internal panel mounting hardware, grounding hardware, and sealing washers.
8. Grounding stud on enclosure body.
9. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall-Mounted, NEMA 250, Types 4 and 12:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - b. **[Hammond Mfg. Co. Inc]**
 - c. **[Hoffman; brand of nVent Electrical plc]**
 - d. **[Saginaw Control and Engineering]**
 - e. **<Insert manufacturer's name>**
2. NRTL listed in accordance with UL 508A.
3. Seam and joints are continuously welded and ground smooth.
4. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
5. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
6. Single-door enclosure sizes up to **60 inches tall by 36 inches wide**.
7. Double-door enclosure sizes up to **36 inches tall by 60 inches wide**.
8. Construct enclosure of steel, not less than the following:
 - a. Size Less Than 24 Inches (600 mm): **[0.053 inch][or][0.067 inch]** thick.
 - b. Size 24 Inches (600 mm) and Larger: **0.067 inch** thick.
9. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior Color: **[White][Gray][Selected by Architect][Manufacturer's standard]<Insert**

- color>.**
- b. Interior Color: **[White][Gray][Manufacturer's standard]**.
10. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
 - a. Sizes through 24 Inches (600 mm) Tall: Two hinges.
 - b. Sizes between 24 Inches (600 mm) through 48 Inches (1200 mm) Tall: Three hinges.
 - c. Sizes Larger Than 48 Inches (1200 mm) Tall: Four hinges.
 11. Double-door enclosures with overlapping door design to include unobstructed full-width access.
 - a. Single-door enclosures **48 inches** and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.
 12. Removable internal panel with **[white][or][gray]** polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Size Less Than 24 Inches (600 mm): **[Solid][or][perforated]** steel, **0.053 inch** thick.
 - b. Size 24 Inches (600 mm) and Larger: Solid **[aluminum, 0.10 inch][or][steel, 0.093 inch]** thick.
 13. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
 14. Grounding stud on enclosure body.
 15. Thermoplastic pocket on inside of door for record Drawings and Product Data.
- F. Wall-Mounted, NEMA 250, Type 4X-SS:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - b. **[Hammond Mfg. Co. Inc]**
 - c. **[Hoffman; brand of nVent Electrical plc]**
 - d. **[Saginaw Control and Engineering]**
 - e. **<Insert manufacturer's name>**
 2. NRTL listed in accordance with UL 508A.
 3. Seams and joints are continuously welded and ground smooth.
 4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
 5. Construct enclosure of **[Type 304][or][Type 316L]** stainless steel, not less than the following:
 - a. Size Less Than 24 Inches (600 mm): **0.053 inch** thick.
 - b. Size 24 Inches (600 mm) and Larger: **0.067 inch** thick.
 6. Outside body and door of enclosure with brushed No. 4 finish.
 7. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
 - a. Sizes through 24 Inches (600 mm) Tall: Two hinges.
 - b. Sizes between 24 Inches (600 mm) through 48 Inches (1200 mm) Tall: Three hinges.
 - c. Sizes Larger Than 48 Inches (1200 mm) Tall: Four hinges.

8. Corner-formed door, full size of enclosure face, supported using continuous piano hinge full length of door.
9. Doors fitted with three-point (top, middle, and bottom) latch system with single, heavy-duty, liquidtight, **[Type 304][or][Type 316L]** stainless steel handle with integral locking mechanism.
10. Removable internal panel of **0.093-inch** stainless steel.
11. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
12. Install corrosion-resistant polyester vent drain in a stainless steel sleeve at bottom of enclosure.
13. Include enclosure with stainless steel mounting brackets.

G. Freestanding, NEMA 250, Type 1:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - b. **[Hammond Mfg. Co. Inc]**
 - c. **[Hoffman; brand of nVent Electrical plc]**
 - d. **[Saginaw Control and Engineering]**
 - e. **<Insert manufacturer's name>**
2. NRTL listed in accordance with UL 508A.
3. Seams and joints are continuously welded and ground smooth.
4. Externally formed body flange around perimeter of enclosure face.
5. Single-door enclosure sizes up to **84 inches tall by 36 inches wide**.
6. Double-door enclosure sizes up to **84 inches tall by 72 inches wide**.
7. Construct enclosure of steel, not less than **0.067 inch** thick.
8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior Color: **[White][Gray][Selected by Architect][Manufacturer's standard]<Insert color>**.
 - b. Interior Color: **[White][Gray][Manufacturer's standard]**.
9. Corner-formed flush door, full size of enclosure face, supported using four concealed hinges with easily removable hinge pins.
10. Double-door enclosures with overlapping door design to include unobstructed full-width access.
11. Doors with three-point (top, middle, and bottom) latch system with single heavy-duty handle and integral locking mechanism.
12. Removable back covers.
13. Removable solid steel internal panel, **0.093 inch** thick, with **[white][or][gray]** polyester powder coating that is electrostatically applied and then baked to bond to substrate.
14. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
15. Grounding stud on enclosure body.
16. Thermoplastic pocket on inside of door for record Drawings and Product Data.
17. Nominal **4-inch-** tall integral lifting base, not less than **0.123 inch** thick, with predrilled holes for attachment to mounting surface.
18. Equip each top end of enclosure with lifting tabs, not less than **0.172 inch** thick, or not less than two lifting eyes.
19. Internal rack-mount shelves and angles, as required by application.

H. Freestanding, NEMA 250, Types 4 and 12:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Cooper B-line; brand of Eaton, Electrical Sector]
 - b. [Hammond Mfg. Co. Inc]
 - c. [Hoffman; brand of nVent Electrical plc]
 - d. [Saginaw Control and Engineering]
 - e. <Insert manufacturer's name>
2. NRTL listed in accordance with UL 508A.
 3. Seams and joints are continuously welded and ground smooth.
 4. Externally formed body flange around perimeter of enclosure face.
 5. Type 12 Enclosure Sizes:
 - a. Single-door enclosure sizes up to **90 inches tall by 36 inches wide**.
 - b. Double-door enclosure sizes up to **90 inches tall by 72 inches wide**.
 6. Type 4 Enclosure Sizes:
 - a. Single-door enclosure sizes up to **72 inches tall by 36 inches wide**.
 - b. Double-door enclosure sizes larger than **36 inches wide**.
 7. Construct enclosure of steel, not less than **0.093 inch** thick.
 8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior Color: [White][Gray][Selected by Architect][Manufacturer's standard]<Insert color>.
 - b. Interior Color: [White][Gray][Manufacturer's standard].
 9. Corner-formed door with continuous perimeter oil-resistant gasket supported using continuous piano hinge full length of door.
 10. Doors fitted with three-point (top, middle, and bottom) latch system with latching rod rollers and single, heavy-duty, oiltight handle with integral locking mechanism.
 11. Removable solid steel internal panel, **0.093 inch** thick, with [white][or][gray] polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 12. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
 13. Grounding stud on enclosure body.
 14. Thermoplastic pocket on inside of door for record Drawings and Product Data.
 15. Equip top of enclosure with no fewer than two lifting eyes.
 16. Internal rack-mount shelves and angles, as required by application.
- I. Freestanding, NEMA 250, Type 4X-SS:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - b. [Hammond Mfg. Co. Inc]
 - c. [Hoffman; brand of nVent Electrical plc]
 - d. [Saginaw Control and Engineering]
 - e. <Insert manufacturer's name>

2. NRTL listed in accordance with UL 508A.
3. Seams and joints are continuously welded and ground smooth.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Construct enclosure of **[Type 304][or][Type 316L]** stainless steel, not less than the following:
 - a. Size Less Than 24 Inches (600 mm): **0.053 inch** thick.
 - b. Size 24 Inches (600 mm) and Larger: **0.067 inch** thick.
6. Outside enclosure and door of enclosure with brushed No. 4 finish.
7. Doors:
 - a. Single-door enclosure sizes up to **36 inches** wide.
 - b. Double-door enclosure sizes larger than **36 inches** wide.
 - c. Corner-formed door(s) with continuous perimeter oil-resistant gasket, full size of enclosure face, supported using continuous piano hinge full length of door.
 - d. Doors fitted with three-point (top, middle, and bottom) latch system with single, heavy-duty, liquidtight, **[Type 304][or][Type 316L]** stainless steel handle with integral locking mechanism.
8. Removable internal panel of **0.093-inch** stainless steel.
9. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
10. Install corrosion-resistant polyester vent drain in a stainless steel sleeve at bottom of enclosure.
11. Include enclosure with stainless steel mounting brackets.
12. Thermoplastic pocket on inside of door for record Drawings and Product Data.
13. Equip top of enclosure with no fewer than two lifting eyes.
14. Internal rack-mount shelves and angles, as required by application.

J. Accessories:

1. Electric Heater:
 - a. Aluminum housing with brushed finish.
 - b. Thermostatic control with adjustable set point from **0 to 100 deg F**.
 - c. Capacity: 100, 200, 400, and 800 W, as required by application.
 - d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.
2. Ventilation Fans, Filtered Intake, and Exhaust Grilles:
 - a. Number and size of fans, filters, and grilles, as required by application.
 - b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
 - c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
 - d. Thermostatic control with adjustable set point from **32 to 140 deg F**.
 - e. Airflow Capacity at Zero Pressure:
 - 1) 4-Inch (100-mm) Fan: **100 cfm**.
 - 2) 6-Inch (150-mm) Fan: **240 cfm**.
 - 3) 10-Inch (250-mm) Fan: **560 cfm**.
 - f. Maximum operating temperature of **158 deg F**.
 - g. **4-inch** fan thermally protected and provided with permanently lubricated ball-bearings.

- h. **6- and 10-inch** fans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.
 - i. Dynamically balanced impellers molded from polycarbonate material.
 - j. Fan furnished with power cord and polarized plug for power connection.
 - k. Fan brackets, finger guards, and mounting hardware provided with fans to complete installation.
 - l. Removable Intake and Exhaust Grilles: **[ABS plastic][or][stainless steel]**, of size to match fan size and suitable for NEMA 250, Types 1 and 12 enclosures.
 - m. Filters for NEMA 250, Type 1 Enclosures: Washable **[foam][or][aluminum]**, of size to match intake grille.
 - n. Filters for NEMA 250, Type 12 Enclosures: Disposable, of size to match intake grille.
- 3. Air Conditioner:
 - a. Electric-powered, self-contained, air-conditioning unit specially designed for electrical enclosures to maintain temperature inside enclosure below ambient temperature outside enclosure.
 - b. Thermostatic control with adjustable set point from **60 to 120 deg F**.
 - c. Enclosure side or top mounting with unit capacity, as required by application.
 - d. Designed for closed-loop cooling with continuous operation in ambient environments up to **125 deg F**.
 - e. HFC refrigerant.
 - f. Reusable and washable air filter.
 - g. High-performance, industrial-grade, and high-efficiency fans.
 - h. Furnished with power cord and polarized plug for power connection.
 - i. Condensate management system with base pan side drain.
 - j. Mounting hardware, gaskets, mounting template, and instruction manual furnished with unit.
 - k. Outdoor units equipped with head pressure control for low ambient operation, compressor heater, coated condenser coil, and thermostat.
- 4. Thermoelectric Humidifier:
 - a. ABS plastic enclosure.
 - b. Capacity of **8 oz.** of water per 24 hours.
 - c. Built-in drain captures moisture and plastic hose directs moisture to outside enclosure through a drain.
 - d. Controlled to maintain enclosure relative humidity at adjustable set point.
 - e. Unit power supply is internally wired to enclosure electrical power source.
- 5. Framed Fixed Window Kit for NEMA 250, Types 4, 4X, and 12 Enclosures:
 - a. **0.25-inch-** thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
 - b. Enclosure types, except NEMA 250 Type 1, to have continuous gasket material around perimeter of window and frame to provide watertight seal.
 - c. Window kit to be factory or shop installed before shipment to Project.
- 6. Frameless Fixed Window Kit for NEMA 250, Type 1 Enclosures:
 - a. **0.125-inch-** thick, polycarbonate window mounted in enclosure door material.
 - b. Window attached to door with screw fasteners and continuous strip of high-strength, double-sided tape around window perimeter.
 - c. Window kit is factory or shop installed before shipment to Project.
- 7. Frame Fixed or Hinged Window Kit for NEMA 250, Types 1 and 12 Enclosures:

- a. **0.25-inch-** thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
 - b. Enclosure types, except NEMA 250 Type 1, to have continuous gasket material around perimeter of window and frame to provide watertight seal.
 - c. Window kit to be factory or shop installed before shipment to Project.
8. Bar handle with keyed cylinder lock set.

2.30 RELAYS

A. General-Purpose Relays:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Allen Bradley; by Rockwell Automation]**
 - b. **[Eaton]**
 - c. **[IDEC Corporation]**
 - d. **[Omron Americas]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. NRTL listed.
3. Heavy-duty, electromechanical type; rated for at least **[10]<Insert value>** A at 250 V ac and 60 Hz.
4. SPDT, DPDT, or three-pole double-throw, as required by control application.
5. Plug-in-style relay with **[8-pin octal][or][multiblade]** plug for DPDT relays and **[11-pin octal][or][multiblade]** plug for three-pole double-throw relays.
6. Construct contacts of silver, silver alloy, or gold.
7. Enclose relay in a **[clear transparent]** polycarbonate dust-tight cover.
8. Include LED indication **[and push-to-test button to test manual operation of relay without power on coil].**
9. Performance:
 - a. Mechanical Life: At least **[10]<Insert number>** million cycles.
 - b. Electrical Life: At least **[100,000]<Insert number>** cycles at rated load.
 - c. Pickup Time: **[15][20]<Insert value>** ms or less.
 - d. Dropout Time: **[10][20]<Insert value>** ms or less.
 - e. Pull-in Voltage: **[85]<Insert number>** percent of rated voltage.
 - f. Dropout Voltage: **[50][10]<Insert number>** percent of nominal rated voltage.
 - g. Power Consumption: **[2][5]** VA or less.
 - h. Ambient Operating Temperatures: **Minus 40 to 115 deg F.**
10. Equip relays with coil transient suppression to limit transients to non-damaging levels.
11. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
12. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

B. Multifunction Time-Delay Relays:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Allen Bradley; by Rockwell Automation]**
 - b. **[Eaton]**
 - c. **[IDEC Corporation]**
 - d. **[Omron Americas]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. NRTL listed.
3. Continuous-duty type, rated for at least **[10]<Insert value>** A at 240 V ac and 60 Hz.
4. Relay with up to **[4][8]<Insert number>** programmable functions to provide on/off delay, interval, and recycle timing functions.
5. Plug-in-style relay with either multi-pin or blade plug.
6. Construct contacts of silver, silver alloy, or gold.
7. Enclose relay in a dust-tight cover.
8. Include knob and dial scale for alternative digital interface for setting delay time.
9. Visual Status Indication: Power "On" **[and Output "On"]** status.
10. Performance:
 - a. Mechanical Life: At least **[10]<Insert number>** million cycles.
 - b. Electrical Life: At least **[100,000]<Insert number>** cycles at rated load.
 - c. Timing Ranges: Multiple ranges from **[0.1]<Insert number>** seconds to **[100]<Insert number>** minutes.
 - d. Repeatability: Within **[2]<Insert number>** percent.
 - e. Recycle Time: **[45]<Insert value>** ms.
 - f. Minimum Pulse-Width Control: **[50]<Insert value>** ms.
 - g. Power Consumption: 5 VA or less.
 - h. Ambient Operating Temperatures: **Minus 40 to 115 deg F.**
11. Equip relays with transient suppression to limit transients to non-damaging levels.
12. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
13. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

C. Latching Relays:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Allen Bradley; by Rockwell Automation]**
 - b. **[Eaton]**
 - c. **[IDEC Corporation]**
 - d. **[Omron Americas]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. NRTL listed.

3. Continuous-duty type, rated for at least [10]<Insert value> A at 250 V ac and 60 Hz.
4. SPDT, DPDT, or three-pole double-throw, as required by control application.
5. Plug-in-style relay with either multi-pin or blade plug.
6. Construct contacts of silver, silver alloy, or gold.
7. Enclose relay in a [clear transparent]polycarbonate dust-tight cover.
8. Performance:
 - a. Mechanical Life: At least [10]<Insert number> million cycles.
 - b. Electrical Life: At least [100,000]<Insert number> cycles at rated load.
 - c. Pickup Time: [15][20]<Insert value> ms or less.
 - d. Dropout Time: [10][20]<Insert value> ms or less.
 - e. Pull-in Voltage: [85]<Insert number> percent of rated voltage.
 - f. Dropout Voltage: [50][10]<Insert number> percent of nominal rated voltage.
 - g. Power Consumption: [2][5]<Insert value> VA or less.
 - h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
10. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

D. Current Sensing Relays:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Eaton]
 - b. [Functional Devices Inc]
 - c. [NK Technologies]
 - d. [Square D; Schneider Electric USA]
 - e. <Insert manufacturer's name>
2. NRTL listed.
3. Monitors ac current.
4. Independent adjustable controls for pickup and dropout current.
5. Energized when supply voltage is present and current is above pickup setting.
6. De-energizes when monitored current is below dropout current.
7. Dropout current is adjustable from [50]<Insert number> to [95]<Insert number> percent of pickup current.
8. Visual indication of contact status.
9. Include current transformer, if required for application.
10. House current sensing relay and current transformer if required in its own enclosure. Use NEMA 250, [Type 1][or][Type 12] enclosure for indoors applications and NEMA 250, [Type 4][or][Type 4X] for outdoor applications.

E. Combination On-Off Status Sensor and On-Off Control Relays:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Functional Devices Inc]

- b. [Veris Industries]
 - c. <Insert manufacturer's name>
2. Description:
- a. On-off control and on-off status indication in a single device.
 - b. LED status indication of activated relay and current trigger.
 - c. Closed-Open-Auto override switch located on the load side of relay.
3. Performance:
- a. Ambient Temperature: **Minus 30 to 140 deg F.**
 - b. Voltage Rating: Single-phase loads rated for 300 V ac. Three-phase loads rated for 600 V ac.
4. Status Indication:
- a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
 - b. Current Sensor Range: As required by application.
 - c. Current Set Point: [Fixed][Adjustable][Fixed or adjustable, as required by application].
 - d. Current Sensor Output:
 - 1) Solid-state, SPDT contact rated for 30 V ac and dc and for 0.4 A.
 - 2) Solid-state, SPDT contact rated for 120 V ac and 1.0 A.
 - 3) Analog, 0 to 5 or 10 V dc.
 - 4) Analog, 4 to 20 mA, loop powered.
5. Relay: SPDT, continuous-duty coil; rated for 10-million mechanical cycles.
6. Enclosure: NEMA 250, [Type 1][Type 12]<Insert type> enclosure for indoor applications; NEMA 250, [Type 4][Type 4X]<Insert type> enclosure for outdoor applications.

2.31 ELECTRICAL POWER DEVICES

A. Control Transformers:

- 1. Sizing Criteria: Size control transformers for total connected load, plus additional [25][50]<Insert number> percent of connected load for future spare capacity.
- 2. Transformer Minimum Capacity: [40][100]<Insert value> VA.
- 3. Protection: Provide transformers with both primary and secondary fuses. [Integral circuit breaker is acceptable in lieu of fuses.]
- 4. Enclosure: House control transformers in NEMA 250 enclosures, type as indicated in "Performance Requirements" Article for application.

B. Power-Line Conditioners:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Eaton]
 - b. [Emerson Electric Co., Automation Solutions]
 - c. [SolaHD; Emerson Electric Co., Automation Solutions]
 - d. <Insert manufacturer's name>

2. General Power-Line Conditioner Requirements:
 - a. Design to ensure maximum reliability, serviceability, and performance.
 - b. Overall function of power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. Power-line conditioner is to provide isolated, regulated, transient, and noise-free sinusoidal power to loads served.
3. Standards: NRTL listed per UL 1012.
4. Performance:
 - a. Single phase, continuous, 100 percent duty rated kVA/kW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
 - b. Automatically regulate output voltage to within [2]<Insert number> percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.
 - 1) At 75 Percent Load: Output voltage automatically regulated to within [3]<Insert number> percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.
 - 2) At 50 Percent Load: Output voltage automatically regulated to within [3]<Insert number> percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
 - 3) At 25 Percent Load: Output voltage automatically regulated to within [3]<Insert number> percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.
 - c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to maximum harmonic content of [5]<Insert number> percent.
 - d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero to 100 to zero percent.
 - e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when output is taken from no load to full-resistive load, or vice versa. Recovery from partial resistive load changes is corrected in a shorter period.
 - f. K Factor: [30]<Insert value>, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
 - g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.
 - h. Attenuate load-generated odd current harmonics [23]<Insert value> dB at the input.
 - i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
 - j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.1 and IEEE C62.41.2.
 - k. Common-mode noise attenuation of [140]<Insert value> dB.
 - l. Transverse-mode noise attenuation of [120]<Insert value> dB.
 - m. With loss of input power for up to 16.6 ms, output sine wave remains at usable ac voltage levels.
 - n. Reliability of [200,000]<Insert number> hours' MTBF.
 - o. At full load, when measured at 1 m distance, audible noise is not to exceed [54]<Insert value> dB.
 - p. Approximately [92]<Insert number> percent efficient at full load.
5. Transformer Construction:
 - a. Ferroresonant, dry type, convection cooled, 600 V class. Transformer windings of Class H

- (220 deg C) insulated copper.
 - b. Use Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40 deg C ambient temperature.
 - c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
 - d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
 - e. Configure transformer secondary in 240/120 V split with 208 V tap or straight 120 V, depending on power output size.
 - f. Electrically isolate the transformer secondary windings from primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.
 - g. Include interface terminals for output power hot, neutral, and ground conductors.
 - h. Label leads, wires, and terminals to correspond with circuit wiring diagram.
 - i. Vacuum impregnate transformer with epoxy resin.
 - 6. Cabinet Construction:
 - a. Design for panel or floor mounting.
 - b. NEMA 250, **[Type 1][or][Type 2]** enclosure for indoor applications. NEMA 250, **[Type 3R]<Insert type>** for outdoor applications.
 - c. Manufacture the cabinet from heavy gauge steel complying with UL 50 or UL 508A.
 - d. Include textured baked-on paint finish.
- C. DC Power Supplies:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acopian Technical Company]**
 - b. **[Emerson Electric Co., Automation Solutions]**
 - c. **[IDEC Corporation]**
 - d. **[Omron Americas]**
 - e. **<Insert manufacturer's name>**
 - 2. Description: Linear or switched, regulated power supplies with ac input to **[one][or][multiple]** dc output(s).
 - a. Include both line and load regulation to ensure stable output.
 - b. To protect both power supply and load, include power supply with an automatic current limiting circuit.
 - 3. Features:
 - a. Connection: Plug-in style suitable for mating with standard **[8-pin octal]** socket. Include power supply with mating mounting socket.
 - b. Housing: Enclose circuitry in a housing.
 - c. Local Adjustment: Include screw adjustment on exterior of housing for dc voltage output.
 - d. Mounting: DIN rail.
 - e. Visual status indicator.
 - f. **<Insert feature>**.
 - 4. Performance:
 - a. Input Voltage: Nominally **[120]<Insert value>** V ac, 60 Hz.

- b. Output Voltage: Nominally [24]<Insert value> V dc with plus or minus [1]<Insert value> V dc adjustment.
- c. Output Current: Minimum [100]<Insert value> mA.
- d. Load Regulation: Within [0.1]<Insert number> percent.
- e. Line Regulation: Within [0.05]<Insert number> percent.
- f. Stability: Within [0.1]<Insert number> percent of rated volts after warmup period.
- g. Ripple: [1]<Insert value> mV rms.

2.32 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

- A. Furnish local UPS units, of type indicated, installed with DDC system.
- B. DIN Rail Mounted UPS:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[APC by Schneider Electric]**
 - b. **[Emerson Electric Co., Automation Solutions]**
 - c. **[Phoenix Contact]**
 - d. **<Insert manufacturer's name>**
 - 2. Provide continuous, regulated output power without using batteries during brown-out, surge, and spike conditions.
 - 3. Performance:
 - a. Capacity: Load not to exceed [75]<Insert number> percent of rated capacity.
 - b. Efficiency: Minimum [94]<Insert number> percent.
 - c. Input Voltage: Single phase, 120 V ac, compatible with field power source.
 - d. Load Power Factor Range (Crest Factor): **[0.65 to 1.0]<Insert range>**.
 - e. Output Voltage: 101 to 132 V ac, while input voltage varies between 89 and 152 V ac.
 - f. On Battery Output Voltage: Sine wave.
 - g. Inverter Overload Capacity: Minimum [150]<Insert number> percent for 30 seconds.
 - h. Battery Backup: **[Five][10][15]<Insert number> minutes of operation at [full]<Insert value> load with battery power.**
 - i. Battery Recharge Time: Maximum of [four][six]<Insert number> hours to 90 percent capacity after full discharge.
 - j. Transfer Time: [6]<Insert value> ms.
 - k. Surge Voltage Withstand Capacity: IEEE C62.41.1 and IEEE C62.41.2, Categories A and B.
 - 4. Automatic bypass operation during fault or overload conditions.
 - 5. Integral line-interactive, power condition topology to eliminate all power contaminants.
 - 6. Include power switch and visual indication of power, battery, fault[, and temperature].
 - 7. Include audible alarm of faults with silence feature.
 - 8. Include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure)[and connect points to DDC system].
 - 9. Batteries: Sealed; maintenance free; replacement without dropping load.
- C. Tower UPS Models through 1000 VA:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. **[APC by Schneider Electric]**
 - b. **[Eaton]**
 - c. **[Toshiba International Corporation]**
 - d. **<Insert manufacturer's name>**
2. Provide continuous, regulated output power without using batteries during brown-out, surge, and spike conditions.
 3. Performance:
 - a. Capacity: Load not to exceed **[75]<Insert number>** percent of rated capacity.
 - b. Efficiency: Complying with ENERGY STAR requirements; minimum **[91]<Insert number>** percent.
 - c. Input Voltage: Single phase, 120 V ac, compatible with field power source.
 - d. Load Power Factor Range (Crest Factor): **[0.65 to 1.0]<Insert range>**.
 - e. Output Voltage: 101 to 132 V ac, while input voltage varies between 89 and 152 V ac.
 - f. On Battery Output Voltage: Sine wave.
 - g. Inverter Overload Capacity: Minimum **[150]<Insert number>** percent for 30 seconds.
 - h. Battery Backup: **[Five][10][15]<Insert number>** minutes of operation at **[full]<Insert value>** load with battery power.
 - i. Battery Recharge Time: Maximum of **[four][six]<Insert number>** hours to 90 percent capacity after full discharge to cutoff.
 - j. Transfer Time: **[0]<Insert value>** ms.
 - k. Surge Voltage Withstand Capacity: IEEE C62.41.1 and IEEE C62.41.2, Categories A and B; 6 kV/200 and 500 A; 100 kHz ring wave.
 4. Automatic bypass operation during fault or overload conditions.
 5. Integral line-interactive, power condition topology to eliminate all power contaminants.
 6. Include power switch and visual indication of power, battery, fault, and temperature.
 7. Include audible alarm of faults and front panel silence feature.
 8. Receptacles: Minimum **[four]<Insert number>**, NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.
 9. Remote Alarms: Include dry contacts (digital output points) **[or serial communication interface]**for low battery condition and battery-on (primary utility power failure)**[and connect points to DDC system]**.
 10. Batteries: Sealed type; maintenance free. Battery replacement is to be front accessible by user without dropping load.
 11. Install tower models in enclosures rated for location.
- D. UPS Models through 3000 VA: **[Tower][and][Rack]**.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[APC by Schneider Electric]**
 - b. **[Eaton]**
 - c. **[Toshiba International Corporation]**
 - d. **<Insert manufacturer's name>**
 2. NRTL Listing: UL 1778.
 3. Provide continuous, regulated output power without using batteries during brown-out, surge, and

- spike conditions.
4. Performance:
 - a. Capacity: Load not to exceed **[75]<Insert number>** percent of UPS rated capacity.
 - b. Efficiency: Complying with ENERGY STAR requirements; minimum **[91]<Insert number>** percent.
 - c. Input Voltage: Single phase, 120 V ac, plus 20 to minus 30 percent.
 - d. Power Factor: Minimum **[0.95]<Insert value>** at full load.
 - e. Output Voltage: Single phase, 120 V ac, within **[2][3]** percent.
 - f. Inverter overload capacity to be minimum **[150]<Insert number>** percent for 30 seconds.
 - g. Battery Backup: **[Five][10][15]<Insert number>** minutes of operation at **[full]<Insert value>** load with battery power.
 - h. Battery Recharge Time: Maximum of **[6][8]<Insert number>** hours to 90 percent capacity.
 - i. Transfer Time: **[0]<Insert value>** ms.
 - j. **<Insert additional performance requirement>**.
5. LCD display with operator interface.
6. Receptacles: Minimum **[6]<Insert number>**, NEMA WD 1, NEMA WD 6 Configuration 5-15R or 5-20R receptacles.
7. Automatic bypass operation during fault or overload conditions.
8. Remote Alarms: Include dry contacts (digital output points) **[or serial communication interface]**for low battery condition and battery-on (primary utility power failure)**[and connect points to DDC system]**.
9. Batteries: Sealed; maintenance free.
10. Enclosures: Install tower models in enclosures rated for location.**[Install rack models installed on matching racks, as applicable to particular installation location and space availability/configuration.]**

2.33 PRESSURE INSTRUMENT SIGNAL AIR PIPING AND TUBING

- A. Products in this article are intended for use with the following:
 1. Main air and signal air to pneumatically controlled instruments, actuators, and other control devices and accessories.
 2. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers, and accessories.
- B. Copper Tubing:
 1. Seamless phosphor deoxidized copper, drawn tempered**[, or soft annealed]**, with chemical and physical properties in accordance with ASTM B75/B75M.
 2. Performance, dimensions, weight, and tolerance in accordance with ASTM B280.
 3. Diameter, as required by application, not less than nominal **[1/4 inch][3/8 inch]<Insert size>**.
 4. Wall thickness, as required by application, but not less than **0.030 inch**.
 5. Copper Tubing Connectors and Fittings - Brass, Compression Type:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[BrassCraft Manufacturing Co.; a Masco company]**
 - 2) **[DK-LOK USA]**
 - 3) **[Mid-America Fittings, LLC; A Midland Industries Company]**

- 4) **[Parker (Parker Hannifin)]**
- 5) **<Insert manufacturer's name>**
- b. Single or double ferrule design creating a constant tension between fitting body and fitting nut for leak-free seal.
6. Copper Tubing Connectors and Fittings - Copper, Solder-Joint Type:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]**
 - 2) **[NIBCO INC.]**
 - 3) **[Paul Mueller Company]**
 - 4) **<Insert manufacturer's name>**
 - b. Copper Solder-Joint Fittings: Cast, ASME B16.18 or wrought, ASME B16.22.
- C. Galvanized-Steel Piping (for Pneumatic/Pressure Instrument Signal Air):
 1. Pipe: ASTM A53/A53M, Schedule 40.
 2. Fittings: Galvanized malleable iron, ASME B16.3, Class 150.
- D. Polyethylene Tubing: (**[For Pneumatic]/**Pressure Instrument Signal Air).
 1. Fire-resistant, black virgin polyethylene in accordance with ASTM D1248, Type 1, Class C, and Grade 5.
 2. Complying with stress crack test in accordance with ASTM D1693.
 3. Diameter, as required by application, of not less than nominal **1/4 inch**.
 4. Polyethylene Tubing Connectors and Fittings - Brass, Barb Fittings:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[BrassCraft Manufacturing Co.; a Masco company]**
 - 2) **[DK-LOK USA]**
 - 3) **[Mid-America Fittings, LLC; A Midland Industries Company]**
 - 4) **[Parker (Parker Hannifin)]**
 - 5) **<Insert manufacturer's name>**
 - b. Tapered and beaded hose barbs of push-on design; intended for low-pressure applications only.
5. Polyethylene Tubing Connectors and Fittings - Brass, Compression Type:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[BrassCraft Manufacturing Co.; a Masco company]**
 - 2) **[DK-LOK USA]**



- 3) **[Mid-America Fittings, LLC; A Midland Industries Company]**
- 4) **[Parker (Parker Hannifin)]**
- 5) **<Insert manufacturer's name>**

- b. Specially designed for jointing polyethylene tubing to provide leak-free seal without twisting or weakening polyethylene tubing.

2.34 PROCESS TUBING

- A. Products in this article are intended for signals to instruments connected to liquid and steam systems.

B. Copper Tubing:

1. Seamless phosphor deoxidized copper, drawn tempered with chemical and physical properties in accordance with ASTM B75/B75M.
2. Performance, dimensions, weight, and tolerance in accordance with ASTM B280.
3. Diameter, as required by application, of not less than nominal **[3/8 inch][1/2 inch]<Insert size>**.
4. Wall thickness, as required by application, but not less than **0.030 inch**.
5. Copper Tubing Connectors and Fittings (for Process Tubing) - Brass, Compression Type:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) **[BrassCraft Manufacturing Co.; a Masco company]**
- 2) **[DK-LOK USA]**
- 3) **[Mid-America Fittings, LLC; A Midland Industries Company]**
- 4) **[Parker (Parker Hannifin)]**
- 5) **<Insert manufacturer's name>**

- b. Single or double ferrule design creating a constant tension between fitting body and fitting nut for leak-free seal.

6. Copper Tubing Connectors and Fittings (for Process Tubing) - Brass, Solder-Joint Type:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) **[Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]**
- 2) **[NIBCO INC.]**
- 3) **<Insert manufacturer's name>**

- b. Copper Solder-Joint Fittings: Cast, ASME B16.18 or wrought, ASME B16.22.

C. Stainless Steel Tubing (for Process Tubing):

1. Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, and free from scale.
2. Chemical and physical properties in accordance with ASTM A269/A269M.
3. Diameter, as required by application, of not less than nominal **[3/8 inch][1/2 inch]<Insert size>**.
4. Wall thickness, as required by application, but not less than **0.035 inch**.

5. Furnish stainless steel tubing in [20 ft.] straight random lengths.
 - D. Stainless Steel Tubing Connectors and Fittings (for Process Tubing) - Stainless Steel, Compression Type:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[DK-LOK USA]**
 - b. **[Parker (Parker Hannifin)]**
 - c. **[Sizto Tech Corporation (STC)]**
 - d. **<Insert manufacturer's name>**
 2. Connectors and fittings constructed from Type 316 stainless steel, with collets, flareless type.
 3. Single or double ferrule design creating a constant tension between fitting body and fitting nut for leak-free seal.
 4. Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.
- 2.35 CONTROL WIRE AND CABLE
- A. Wire: Single conductor control wiring above 24 V.
 1. Wire Size: Minimum [18][16][14]<Insert value> AWG.
 2. Conductors: 7/24 soft annealed copper strand with **2- to 2.5-inch** lay.
 3. Conductor Insulation: 600 V, Type THWN or Type THHN, and 90 deg C in accordance with UL 83.
 4. Conductor Insulation Colors: Black (hot), white (neutral), and green (ground).
 5. Furnish on spools.
 - B. Single, Twisted-Shielded, Instrumentation Cable above 24 V:
 1. Wire Size: Minimum [18][20][22]<Insert value> AWG.
 2. Conductors: Twisted, 7/24 soft annealed copper strand with a **2- to 2.5-inch** lay.
 3. Conductor Insulation: Type THHN/THWN or Type TFN rating.
 4. Conductor Insulation Colors:
 - a. Twisted Pair: Black and white.
 - b. Twisted Triad: Black, red, and white.
 5. Shielding: 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 6. Outer Jacket Insulation: 600 V, 90 deg C rating, and Type TC cable.
 7. Furnish on spools.
 - C. Single, Twisted-Shielded, Instrumentation Cable 24 V and Less:
 1. Wire Size: Minimum [18][20][22]<Insert value> AWG.
 2. Conductors: Twisted, 7/24 soft annealed copper stranding with a **2- to 2.5-inch** lay.
 3. Conductor Insulation: Nominal 15-mil thickness, constructed from flame-retardant PVC.
 4. Conductor Insulation Colors:
 - a. Twisted Pair: Black and white.

b. Twisted Triad: Black, red, and white.

5. Shielding: 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
6. Outer Jacket Insulation: 300 V, 105 deg C rating, and Type PLTC cable.
7. Furnish on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Comply with following requirements for balanced twisted pair cable described in [Section 260523 "Control-Voltage Electrical Power Cables."] [Section 271513 "Communications Copper Horizontal Cabling."]
 - a. Plenum rated.
 - b. Unique color that is different from other cables used on Project.

2.36 RACEWAYS

- A. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems" for electrical power raceways and boxes.
- B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cables and optical fiber cables.

2.37 OPTICAL FIBER CABLE AND CONNECTORS

- A. Comply with requirements in Section 271323 "Communications Optical Fiber Backbone Cabling" for optical fiber backbone cabling and connectors.
- B. Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber horizontal cabling and connectors.

2.38 ACCESSORIES

- A. Pneumatic Pressure Gauges:
 1. Face Size: **1.5-inch-** diameter face for pressures up through **30 psig** and **2.5-inch-** diameter face for greater pressures.
 2. Face Markings: White dial face with black printing; **1 psig** increment for scale ranges through **30 psig** and **2 psig** increment for larger ranges.
 3. Accuracy: Within **[0.5][1]<Insert number>** percent of full-scale range.
 4. Applications: Include separate gauges for branch pressure and main pressure tubing.
- B. Pressure Electric Switches:
 1. Description: Diaphragm-operated, snap-acting switch.
 2. Performance:
 - a. Rating: Resistance loads at **[120]<Insert value>** V ac.
 - b. Set Point: Adjustable from **[3 to 20 psig]<Insert pressure range>**.

- c. Differential: Adjustable from [2 to 6 psig]<Insert pressure range>.
- 3. Body and Switch Housing: Metal.
- C. Control Damper Blade Limit Switches:
 - 1. Application: Sense positive open and/or closed position of damper blades.
 - 2. NEMA 250, [Type 13]<Insert type>, oiltight construction. Install in instrument enclosure where required for additional environmental protection.
 - 3. Arrange for mounting application, and to prevent "over-center" operation.
- D. I/P and E/P Transducers:
 - 1. Commercial Grade:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [ControlAir, Inc.]
 - 2) [Dwyer Instruments, Inc.]
 - 3) [KMC Controls, Inc.]
 - 4) [MAMAC Systems, Inc.]
 - 5) <Insert manufacturer's name>
 - b. Description: Transducer converting an electronic current (I) or voltage (E) AO signal to a proportional [or stepped]pneumatic signal. Unless otherwise required by operating sequence, use 3 to 15 psig pneumatic signal for pneumatic actuation.
 - c. Features:
 - 1) Auto/manual output switch, manual output control, and output pressure gauge.
 - 2) Separate zero and span calibration adjustments.
 - d. Performance:
 - 1) Accuracy: Within [1.0]<Insert number> percent of output span.
 - 2) Linearity: Within [0.5][1.0]<Insert number> percent of output span.
 - 3) Output Capacity: Not less than [550 scim]<Insert value> at 15 psig.
 - 4) Maximum Pressure: [30 psig][40 psig]<Insert value> of supply pressure without damage.
 - 5) Vibration: Construct entire assembly so that shock and vibration will not harm transducer or affect accuracy.
 - e. Applications:
 - 1) Terminal Units: Fan-coil units, VAV units, unit heaters, and <Insert equipment>.
 - 2) <Insert applications>.
 - 2. Industrial Grade:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1) [ControlAir, Inc.]
 - 2) [Fischer; Emerson Electric Co., Automation Solutions]
 - 3) [Marsh Bellofram]
 - 4) <Insert manufacturer's name>
- b. Description: Transducer converting an electronic current (I) or voltage (E) AO signal to a proportional pneumatic signal (P). Unless otherwise required by operating sequence, use **3 to 15 psig** pneumatic signal for pneumatic actuation. Stepped pneumatic signal is unacceptable.
- c. Features:
- 1) Adjustments: Separate zero and span calibration adjustments.
 - 2) Conduit Connections: Nominal **1/2 inch**.
 - 3) Enclosure: NEMA 250, [Type **4X**] <Insert type>.
 - 4) Pressure Gauge: Integral output pressure gauge.
- d. Performance:
- 1) Accuracy: Within [0.5][1.0]<Insert number> percent of output span.
 - 2) Hysteresis: Within [0.5]<Insert number> percent of output span.
 - 3) Linearity: Within [0.5][0.75]<Insert number> percent of output span.
 - 4) Repeatability: Within [0.5]<Insert number> percent of output span.
 - 5) Output Capacity: Not less than [5]<Insert value> scfm at **15 psig**.
 - 6) Air Consumption: Maximum of [5]<Insert value> scfh at **15 psig**.
 - 7) Ambient Temperature: Suitable for operation in ambient temperature range of **minus 20 to 150 deg F**.
 - 8) Pressure: Up to [50 psig]<Insert value> without damage.
 - 9) Vibration: Construct entire assembly so shock and vibration will not harm transducer or affect accuracy.
- e. Applications:
- 1) All applications, except for terminal units and other applications with commercial-grade transducers.
 - 2) <Insert applications>.

E. E/P Switch:

1. Body: Cast aluminum or brass; three pipe body (common, normally open, and normally closed).
2. Internal Components: Brass, copper, steel, or stainless steel.
3. Connections: Barb, or threaded for mating to compression fittings.
4. Rating: **30 psig** when installed in systems below **25 psig**; **150 psig** when installed in systems above **25 psig**.
5. Features: Include coil transient suppression.

F. Instrument Enclosures:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Hammond Mfg. Co. Inc]
 - b. [Hoffman; brand of nVent Electrical plc]
 - c. [Saginaw Control and Engineering]

- d. **<Insert manufacturer's name>**
 - 2. Application: Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
 - 3. Certification: NRTL listed and labeled to UL 50 or UL 508A as applicable.
 - 4. Subpanel:
 - a. Size enclosure with least 25 percent spare area on subpanel.
 - b. Mount instrument(s) within enclosure on internal subpanel(s).
 - 5. Identification: Include on face of enclosure an engraved, laminated phenolic nameplate for each instrument installed within enclosure.
 - 6. Pneumatic Pressure Gauges: Include main pressure gauge and a branch pressure gauge for each pneumatic device installed inside enclosure.
 - 7. Raceways: For enclosures housing multiple instruments, route tubing, cable, and wiring within enclosure in a raceway having continuous removable cover.
 - 8. Access: Provide enclosures larger than **[12 inches]<Insert dimension>** with hinged full-size face cover.
 - 9. Security: Equip enclosures with lock and common key.
- G. Manual Valves:
- 1. Brass Needle Valves:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[BrassCraft Manufacturing Co.; a Masco company]**
 - 2) **[Parker (Parker Hannifin)]**
 - 3) **<Insert manufacturer's name>**
 - b. Pressure Rating: **150 psig**.
 - c. Temperature Rating: **250 deg F**.
 - d. Body: Brass.
 - e. Seat: Brass.
 - f. Handle: Aluminum, brass, or stainless steel T-bar handle.
 - g. Connections: Include tubing connections.
 - h. Applications: Copper and polyethylene pneumatic tubing.
 - 2. Stainless Steel Needle Valves:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[DK-LOK USA]**
 - 2) **[Parker (Parker Hannifin)]**
 - 3) **[Sizto Tech Corporation (STC)]**
 - 4) **<Insert manufacturer's name>**
 - b. Pressure Rating: **5000 psig**.
 - c. Temperature Rating: **450 deg F**.
 - d. Body: Type 316 stainless steel.

- e. Seat: Type 316 stainless steel.
- f. Packing: **[PTFE]<Insert material>**.
- g. Handle: Aluminum or stainless steel T-bar handle.
- h. Connections: Include tubing connections.
- i. Applications: Copper pneumatic tubing; copper and stainless steel process tubing.

3. Bronze Body Ball Valves:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - 2) **[Milwaukee Valve Company]**
 - 3) **[NIBCO INC.]**
 - 4) **<Insert manufacturer's name>**
- b. Standard: MSS SP-110.
- c. SWP Rating: **150 psig**.
- d. CWP Rating: **600 psig**.
- e. Body Design: Two piece.
- f. Body Material: Bronze.
- g. Ends: Threaded.
- h. Seats: PTFE.
- i. Stem: Stainless steel.
- j. Ball: Stainless steel, vented.
- k. Handle: Stainless steel with vinyl grip.
- l. Port: Full.

H. Retractable, Wall-Mounted Cabinet for Portable Workstations:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AtlasIED]**
 - b. **[Lowell Manufacturing Co.]**
 - c. **<Insert manufacturer's name>**
- 2. Description: Surface-mounted or recessed wall cabinet for tilt-out operation of laptop computers and large-format mobile devices.
- 3. Cabinet Load Limit: **[50 lb]<Insert value>**.
- 4. Cabinet Material: Carbon steel.
- 5. Cabinet Finish: Powder-coat epoxy; manufacturer's standard color.
- 6. Features include the following:
 - a. Oil-filled dampers for controlled lowering of equipment to operational position.
 - b. 3RU EIA mounting rails.
 - c. Removable laptop shelf.
 - d. Separate top compartment with mounting area, hinged rail.
 - e. Front ventilation slots.
 - f. Security key lock access.
 - g. Knockouts for conduit connections on top and bottom of cabinet.

h. **<Insert additional features>**.

7. Field Coordination: Provide inside center of backbox with provision to mount a field-furnished and -installed, single-gang electrical outlet box.

2.39 IDENTIFICATION

A. Instrument Air Pipe and Tubing:

1. Engraved tag bearing the following information:
 - a. Service (Example): "Instrument Air."
 - b. Pressure Range (Example): **0 to 30 psig**.
2. Letter size minimum of **[0.25 inch]<Insert dimension>** high.
3. Engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers color-coded blue with contrasting white center exposed by engraving through outer layer.
4. Include tag with brass grommet, chain, and S-hook.

B. Control Equipment, Instruments, and Control Devices:

1. **[Self-adhesive label][Laminated acrylic or melamine plastic sign]** bearing unique identification.
 - a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
2. Letter size as follows:
 - a. Servers: Minimum of **[0.5 inch]<Insert dimension>** high.
 - b. DDC Controllers: Minimum of **[0.5 inch]<Insert dimension>** high.
 - c. Gateways: Minimum of **[0.5 inch]<Insert dimension>** high.
 - d. Repeaters: Minimum of **[0.5 inch]<Insert dimension>** high.
 - e. Enclosures: Minimum of **[0.5 inch]<Insert dimension>** high.
 - f. Electrical Power Devices: Minimum of **[0.25 inch]<Insert dimension>** high.
 - g. UPS units: Minimum of **[0.5 inch]<Insert dimension>** high.
 - h. Accessories: Minimum of **[0.25 inch]<Insert dimension>** high.
 - i. Instruments: Minimum of **[0.25 inch]<Insert dimension>** high.
 - j. Control Damper and Valve Actuators: Minimum of **[0.25 inch]<Insert dimension>** high.
3. Engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers color-coded black with contrasting white center exposed by engraving through outer layer.
4. Fastened with drive pins.
5. Instruments, control devices, and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

C. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tag Size: Minimum **[1.5 inches]<Insert dimension>** in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following

requirements indicated and provided by original manufacturer do not require an additional tag.

D. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as tape banding for conduits. After painting, label cover plate "HVAC Controls"[**using engraved phenolic tag**].
3. For raceways housing pneumatic tubing, add phenolic tag labeled "HVAC Instrument Air Tubing."
4. For raceways housing air signal tubing, add phenolic tag labeled "HVAC Air Signal Tubing."

E. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size at least 14-point type with white lettering on red background.
3. Warning label to read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering to be enclosed in a white line border. Edge of label is to extend at least [0.25 inch]<Insert dimension>beyond white border.

2.40 SOURCE QUALITY CONTROL

- A. Testing Agency: [**Owner will engage**][**Engage**] a qualified testing agency to evaluate the following in accordance with industry standards for each product, and to verify DDC system reliability specified in performance requirements:
1. DDC controllers.
 2. Gateways.
 3. Routers.
 4. <Insert product>.
- B. Product(s) [**and**][**material(s)**] will be considered defective if [**it does**][**they do**] not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
1. Verify compatibility with and suitability of substrates.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

- D. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.
- E. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

- 1. DDC system has communication interface with equipment having integral controls and having communication interface for remote monitoring or control.
- 2. Equipment to Be Connected:
 - a. Domestic water booster pumps specified in Section 221123.13 "Domestic-Water Packaged Booster Pumps."
 - b. Sewage pump stations specified in Section 221343 "Facility Packaged Sewage Pumping Stations."
 - c. Sump pumps specified in Section 221429 "Sump Pumps."
 - d. Air-compressors and air driers specified in Section 221519 "General-Service Packaged Air Compressors and Receivers" and Section 226119 "Compressed-Air Equipment for Laboratory and Healthcare Facilities."
 - e. Domestic water softeners specified in Section 223100 "Domestic Water Softeners."
 - f. Domestic water heaters specified in Section 223300 "Electric, Domestic-Water Heaters" and Section 223400 "Fuel-Fired, Domestic-Water Heaters."
 - g. Vacuum equipment specified in Section 226219 "Vacuum Equipment for Laboratory and Healthcare Facilities."
 - h. Processed water equipment specified in Section 226719 "Processed Water Equipment for Laboratory and Healthcare Facilities."
 - i. Air curtains specified in Section 233433.16 "Industrial Air Curtains."
 - j. Air-terminal units specified in Section 233600 "Air Terminal Units."
 - k. Kitchen hoods specified in Section 233813 "Commercial-Kitchen Hoods."
 - l. Boilers specified in Section 235213 "Electric Boilers."
 - m. Boilers specified in Section 235216 "Condensing Boilers."
 - n. Boilers specified in Section 235223 "Cast-Iron Boilers."
 - o. Boilers specified in Section 235233 "Water-Tube Boilers."
 - p. Boilers specified in Section 235239 "Fire-Tube Boilers."
 - q. Feedwater equipment specified in Section 235313 "Boiler Feedwater Pumps."
 - r. Deaerators specified in Section 235316 "Deaerators."
 - s. Chillers specified in Section 236413.13 "Direct-Fired Absorption Water Chillers."
 - t. Chillers specified in Section 236413.16 "Indirect-Fired Absorption Water Chillers."
 - u. Chillers specified in Section 236416 "Centrifugal Water Chillers."
 - v. Chillers specified in Section 236423.13 "Air-Cooled, Scroll Water Chillers."
 - w. Chillers specified in Section 236423.16 "Water-Cooled, Scroll Water Chillers."
 - x. Chillers specified in Section 236426.13 "Air-Cooled, Rotary-Screw Water Chillers."
 - y. Chillers specified in Section 236426.16 "Water-Cooled, Rotary-Screw Water Chillers."
 - z. Cooling towers specified in Section 236513.13 "Open-Circuit, Forced-Draft Cooling Towers."
 - aa. Cooling towers specified in Section 236513.16 "Closed-Circuit, Forced-Draft Cooling Towers."
 - bb. Cooling towers specified in Section 236514.13 "Open-Circuit, Induced-Draft, Counterflow Cooling Towers."
 - cc. Cooling towers specified in Section 236514.14 "Open-Circuit, Induced-Draft, Crossflow Cooling Towers."
 - dd. Cooling towers specified in Section 236514.16 "Closed-Circuit, Induced-Draft, Counterflow

- Cooling Towers."
- ee. Cooling towers specified in Section 236514.17 "Closed-Circuit, Induced-Draft, Combined-Flow Cooling Towers."
- ff. Heat wheels specified in Section 237223.13 "Packaged Indoor Heat Wheel Energy Recovery Units" and Section 237223.23 "Packaged, Outdoor, Heat Wheel Energy Recovery Units."
- gg. Heat exchangers specified in Section 237223.19 "Packaged Indoor Fixed Plate Energy Recovery Units" and Section 237223.29 "Packaged, Outdoor, Fixed Plate Energy Recovery Units"
- hh. Air-handling units specified in Section 237313.13 "Indoor, Basic Air-Handling Units."
- ii. Air-handling units specified in Section 237313.16 "Indoor, Semi-Custom Air-Handling Units."
- jj. Air-handling units specified in Section 237313.19 "Indoor, Custom Air-Handling Units."
- kk. Heating and ventilating units specified in Section 237333.16 "Indoor, Indirect, Gas-Fired Heating and Ventilating Units."
- ll. Heating and ventilating units specified in Section 237339 "Indoor, Direct-Fired Heating and Ventilating Units."
- mm. Air-handling units specified in Section 237343.16 "Outdoor, Semi-Custom Air-Handling Units."
- nn. Air-handling units specified in Section 237343.19 "Outdoor, Custom Air-Handling Units."
- oo. Roof-top units specified in Section 237416.11 "Packaged, Small-Capacity, Rooftop Air-Conditioning Units."
- pp. Roof-top units specified in Section 237416.13 "Packaged, Large-Capacity, Rooftop Air-Conditioning Units."
- qq. Make-up air units specified in Section 237423.13 "Packaged, Direct-Fired, Outdoor, Heating-Only Makeup-Air Units."
- rr. Make-up air units specified in Section 237423.16 "Packaged, Indirect-Fired, Outdoor, Heating-Only Makeup-Air Units."
- ss. Dedicated outdoor-air units specified in Section 237433 "Dedicated Outdoor-Air Units."
- tt. Packaged terminal air-conditioners specified in Section 238113.11 "Packaged Terminal Air-Conditioners, Through-Wall Units."
- uu. Packaged terminal air-conditioners specified in Section 238113.12 "Packaged Terminal Air-Conditioners, Freestanding Units."
- vv. Packaged terminal air-conditioners specified in Section 238113.13 "Packaged Terminal Air-Conditioners, Outdoor, Wall-Mounted Units."
- ww. Computer-room air-conditioning units specified in Section 238123.11 "Small Capacity (6 Tons (21 kW) and Smaller), Computer-Room Air-Conditioners, Floor-Mounted Units."
- xx. Computer-room air-conditioning units specified in Section 238123.12 "Large Capacity (7 Tons (25 kW) and Larger), Computer-Room Air-Conditioners, Floor-Mounted Units."
- yy. Computer-room air-conditioning units specified in Section 238123.13 "Computer-Room Air Conditioners, Ceiling-Mounted Units."
- zz. Computer-room air-conditioning units specified in Section 238123.14 "Computer-Room Air Conditioners, Console Units."
- aaa. Computer-room, rack-mounted cooling equipment specified in Section 238123.18 "Computer-Room, Rack-Cooling Equipment."
- bbb. Variable refrigerant flow units specified in Section 238129 "Variable-Refrigerant-Flow HVAC Systems."
- ccc. Fan-coil units specified in Section 238219 "Fan Coil Units."
- ddd. Unit ventilators specified in Section 238223 "Unit Ventilators."
- eee. Wetted-element humidifiers specified in Section 238413.16 "Wetted-Element Humidifiers."
- fff. Atomizing humidifiers specified in Section 238413.19 "Atomizing Humidifiers."
- ggg. Direct-steam-injection humidifiers specified in Section 238413.23 "Direct-Steam-Injection Humidifiers."
- hhh. Self-contained steam humidifiers specified in Section 238413.29 "Self-Contained Steam Humidifiers."

- iii. Heat exchanger humidifiers specified in Section 238413.36 "Heat Exchanger Humidifiers."
- jjj. Dehumidification units specified in Section 238416.13 "Outdoor, Mechanical Dehumidification Units" and in Section 238416.16 "Indoor, Mechanical Dehumidification Units."
- kkk. Switchboards specified in Section 262300 "Low-Voltage Switchgear."
- lll. Motor-control centers specified in Section 262419 "Motor-Control Centers."
- mmm. Variable-frequency controllers specified in Section 262923 "Variable-Frequency Motor Controllers."
- nnn. Diesel emergency engine generators specified in Section 263213.13 "Diesel-Engine-Driven Generator Sets."
- ooo. Gaseous emergency engine generators specified in Section 263213.16 "Gas-Engine-Driven Generator Sets."
- ppp. Bi-fuel emergency engine generators specified in Section 263213.19 "Bi-Fuel-Engine-Driven Generator Sets."
- qqq. UPS specified in Section 263353 "Static Uninterruptible Power Supply."
- rrr. Refrigerant monitoring specified in Section 284400 "Refrigerant Detection and Alarm."
- sss. **<Insert equipment and Section number and title>.**

B. Communication Interface to Other Building Systems:

- 1. DDC system communicates with systems having communication interface.
- 2. Systems to Be Connected:
 - a. Elevators specified in Section 142100 "Electric Traction Elevators."
 - b. Elevators specified in Section 142113 "Electric Traction Freight Elevators."
 - c. Elevators specified in Section 142400 "Hydraulic Elevators."
 - d. Elevators specified in Section 142413 "Hydraulic Freight Elevators."
 - e. Escalators specified in Section 143100 "Escalators."
 - f. Automated water treatment systems specified in Section 232500 "HVAC Water Treatment."
 - g. Automated water treatment systems specified in Section 232516 "Water Treatment for Open-Loop Hydronic Systems."
 - h. Automated water treatment systems specified in Section 232519 "Water Treatment for Steam System Feedwater."
 - i. Power monitoring specified in Section 260913 "Electrical Power Monitoring."
 - j. Lighting controls specified in Section 260936 "Modular Dimming Controls."
 - k. Lighting controls specified in Section 260943.16 "Addressable Luminaire Lighting Controls."
 - l. Lighting controls specified in Section 260943.23 "Relay-Based Lighting Controls."
 - m. Fire-alarm system specified in Section 284600 "Fire Detection and Alarm."
 - n. Fire-alarm system specified in Section 284614 "Single- and Multiple-Station Alarms."
 - o. Access controls specified in Section 281300 "Access Control System Software and Database Management."
 - p. Intrusion detection specified in Section 283100 "Intrusion Detection."
 - q. Perimeter security specified in Section 283121 "Area and Perimeter Intrusion Detection."
 - r. **<Insert system and Section number and title>.**

3.3 PREINSTALLATION INTEGRATION TESTING

- A. Perform the following pretesting of other systems and equipment integration with DDC system before field installation:
 - 1. Test all communications in a controlled environment to ensure connectivity.
 - 2. Load software and demonstrate functional compliance with each control sequence of operation indicated.

3. Using simulation, demonstrate compliance with sequences of operation and other requirements indicated including, but not limited to, the following:
 - a. HVAC equipment controlled through DDC system, such as boilers, chillers, pumps, and air-handling units.
 - b. Equipment faults and system recovery with fault annunciation.
 - c. Analog and Boolean value alarming and annunciation.
4. Develop a method for testing interfaces before deployment.
5. Submit documentation supporting compliance upon request.

3.4 DDC SYSTEM INTERFACE WITH EXISTING SYSTEMS

A. Interface with Existing Systems:

1. Interface DDC systems with existing systems to achieve integration indicated.
2. Monitoring and Control of DDC System by Existing Control System:
 - a. Satisfy DDC system performance requirements when monitoring and controlling DDC system by existing control system.
 - b. Operator of existing system to upload, download, monitor, trend, control, and program every I/O point in DDC system from existing control system using existing control system software and operator workstations.
 - c. Make interface so operator of existing system is not required to learn new software for remote monitoring and control from existing control system.
 - d. Make interface of DDC system into existing control system transparent to operators of existing control system and allow operators to **[program, monitor, and control][monitor and control]** DDC system from any operator workstation connected to existing control system.
 - e. **<Insert requirements>**.
3. Integration of Existing Control System into DDC System:
 - a. Satisfy existing control system performance requirements when monitoring and controlling existing control system through DDC system.
 - b. Operator to upload, download, monitor, alarm, report, trend, control, and program every I/O point in existing system from DDC system using operator workstations and software provided. Combined systems to share one database.
 - c. Make interface of existing control system I/O points into DDC system transparent to operators. Make all operational capabilities identical regardless of whether I/O already exists, or I/O is being installed.
 - d. **<Insert requirements>**.

B. Integration with Existing Enterprise System:

1. Interface DDC system with an existing enterprise system to adhere to Owner standards already in-place and to achieve integration.
2. Owner's control system integrator to provide the following services:
 - a. Enterprise system expansion and development of graphics, logs, reports, trends, and other operational capabilities of enterprise system for I/O being added to DDC control system for use by enterprise system operators.
 - b. Limited assistance during commissioning to extent of DDC system integration with existing enterprise system.

- c. Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system.
3. Engage Owner's control system integrator to provide the following services:
 - a. Enterprise system expansion and development of graphics, logs, reports, trends, and other operational capabilities of enterprise system for I/O being added to DDC control system for use by enterprise system operators.
 - b. Limited assistance during commissioning to extent of DDC system integration with existing enterprise system.
 - c. Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system.
4. Control System Integrator Contact Information:
 - a. Company: **<Insert name>**.
 - b. Company Street Address: **<Insert address>**.
 - c. Company Contact: **<Insert name>**.
 - d. Phone Number: **<Insert phone number>**.
 - e. Email Address: **<Insert email address>**.
5. Attend meetings with control system integrator to integrate DDC system.

3.5 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

- A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
- B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
 1. Control dampers, which are specified in Section 230923.12 "Control Dampers."
 2. Airflow sensors and switches, which are specified in Section 230923.14 "Flow Instruments."
 3. Pressure sensors, which are specified in Section 230923.23 "Pressure Instruments."
 4. **<Insert additional control devices>**.
- C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
 1. Control valves, which are specified in Section 230923.11 "Control Valves."
 2. Pipe-mounted flow meters, which are specified in Section 230923.14 "Flow Instruments."
 3. Pipe-mounted sensors, switches, and transmitters. Flow meters are specified in Section 230923.14 "Flow Instruments."
 4. Tank-mounted sensors, switches, and transmitters. Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
 5. Liquid[**and steam**] temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 6. Pipe- and tank-mounted thermowells. Liquid[**and steam**] thermowells are specified in Section 230923.27 "Temperature Instruments."
 7. **<Insert additional control devices>**.

3.6 CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

- A. Deliver the following to air-handling unit manufacturer for factory installation. Include installation instructions to air-handling unit manufacturer[**and supervise installation for compliance with requirements**].
1. **[Programmable application][or][application-specific]** controller.
 2. Unit-mounted DDC control dampers and actuators, which are specified in Section 230923.12 "Control Dampers."
 3. Unit-mounted airflow sensors, switches, and transmitters, which are specified in Section 230923.14 "Flow Instruments."
 4. Unit-mounted gas sensors, and transmitters, which are specified in Section 230923.16 "Gas Instruments."
 5. Unit-mounted leak-detection switches, which are specified in Section 230923.18 "Leak Detection Instruments."
 6. Unit-mounted pressure sensors, switches, and transmitters, which are specified in Section 230923.23 "Pressure Instruments."
 7. Unit-mounted speed sensors, switches, and transmitters, which are specified in Section 230923.24 "Speed Instruments."
 8. Unit-mounted temperature sensors, switches, and transmitters. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 9. Relays.
 10. **<Insert additional control devices>**.
- B. Deliver the following to terminal unit manufacturer for factory installation. Include installation instructions to terminal unit manufacturer.
1. **[Programmable application][or][application-specific]** controller.
 2. Electric damper actuator. Damper actuators are specified in Section 230923.12 "Control Dampers."
 3. Unit-mounted flow and pressure sensors, transmitters, and transducers. Flow sensors, transmitters, and transducers are specified in Section 230923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
 4. Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 5. Relays.
 6. **<Insert additional control devices>**.
- C. Deliver the following to fan-coil unit manufacturer for factory installation. Include installation instructions to fan-coil unit manufacturer.
1. **[Programmable application][or][application-specific]** controller.
 2. Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 3. Flow and pressure switches. Air and liquid flow sensors, transmitters, and transducers are specified in Section 230923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
 4. Leak-detection switches, which are specified in Section 230923.18 "Leak Detection Instruments."
 5. Relays.
 6. **<Insert control devices>**.

3.7 GENERAL INSTALLATION REQUIREMENTS

- A. Install products to satisfy more stringent of all requirements indicated.

- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Support products, tubing, piping wiring, and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to **<Insert value>** force.
- D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
- E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."
- G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."
- H. Welding Requirements:
 - 1. Restrict welding and burning to supports and bracing.
 - 2. No equipment is cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
 - 3. Welding, where approved, is to be by inert-gas electric arc process and is to be performed by qualified welders in accordance with applicable welding codes.
 - 4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.
- I. Fastening Hardware:
 - 1. Wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.
- K. Corrosive Environments:
 - 1. Avoid or limit use of materials in corrosive airstreams and environments including, but not limited to, the following:
 - a. Laboratory exhaust-air streams.
 - b. Process exhaust-air streams.
 - c. **<Insert conditions>**.
 - 2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Section 260533.13 "Conduits for Electrical Systems," Section 260533.16 "Boxes and Covers for Electrical Systems," and Section 260533.23 "Surface Raceways for Electrical Systems."
 - 3. Where instruments are located in a corrosive airstream and are not already corrosive resistant

from instrument manufacturer, field install products in NEMA 250, Type 4X instrument enclosure constructed of Type 316L stainless steel.

3.8 INSTALLATION OF WORKSTATIONS

A. Desktop Workstation Installation:

1. Install **[Owner-furnished]** workstation(s) at location(s) indicated on Drawings.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single, duplex, electrical power receptacle.
3. Install DDC system software on workstation(s) and verify that software functions properly.
4. Develop Project-specific graphics, trends, reports, logs, and historical database.
5. Power **[each]** workstation through a **[dedicated]** UPS unit. Locate UPS adjacent to workstation.

B. Portable Workstation Installation:

1. Install DDC system software on **[Owner-furnished]** workstation(s) and verify that software functions properly.

C. Color Graphics Application:

1. Use system schematics indicated on Drawings as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's[**and Architect's**] review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Make final editing on-site with Owner's[**and Architect's**] review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

D. Retractable, Wall-Mounted Cabinet for Portable Operator's Workstation Installation:

1. Install retractable, wall-mounted portable operator's workstation cabinet(s) at location(s) indicated on Drawings.
2. Install retractable, wall-mounted portable operator's workstation cabinet(s) at following location(s) and at additional locations indicated on Drawings:
 - a. Each mechanical room.
 - b. Chiller room.
 - c. Boiler room.
 - d. **<Insert location>**.
3. Connect each cabinet to **[120 V, single-phase, 60 Hz]<Insert power requirements>** field power source and install single gang electrical box with **[NEMA WD 6, Type 20R duplex]<Insert receptacle type>** receptacle and metal cover plate in cabinet. Comply with requirements in Section 262726 "Wiring Devices."
4. Connect each cabinet to Ethernet network and install an Ethernet network port for connection to portable operator workstation Ethernet cable. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."



3.9 INSTALLATION OF POT

- A. Install **[one][two]<Insert quantity>** POT(s).
- B. Turn over POTs to Owner at Substantial Completion.
- C. Install software on each POT and verify that software functions properly.

3.10 INSTALLATION OF SERVERS

- A. Install server(s) at location(s) indicated on Drawings.
- B. Install number of servers required to suit requirements indicated. Review Project requirements and indicate layout of proposed server location in Shop Drawings.
- C. Install software indicated on server(s) and verify that software functions properly.
- D. Develop Project-specific graphics, trends, reports, logs, and historical database.
- E. Power servers through **[dedicated]**UPS unit. Locate UPS adjacent to server. Install rack-mounted UPS units for powering rack-mounted servers and tower UPS units for tower servers.

3.11 INSTALLATION OF PRINTERS

- A. Install **[Owner-furnished]**printers at location(s) indicated on Drawings.
- B. Install applicable printer software on **[Owner-furnished]**workstations and verify that software functions properly.

3.12 INSTALLATION OF GATEWAYS

- A. Install gateways if required for DDC system communication interface requirements indicated.
 - 1. Install gateway(s) required to suit indicated requirements.
 - a. **<Insert requirements>**.
- B. Test gateways to verify that communication interface functions properly.

3.13 INSTALLATION OF ROUTERS

- A. Install routers if required for DDC system communication interface requirements indicated.
 - 1. Install router(s) required to suit indicated requirements.
 - a. **<Insert requirements>**.
- B. Test routers to verify that communication interface functions properly.

3.14 INSTALLATION OF CONTROLLERS

- A. Install controllers in enclosures to comply with indicated requirements.
- B. Connect controllers to field power supply[**and to UPS units where indicated**].
- C. Install controllers with latest version of applicable software and configure to execute requirements indicated.
- D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.
- E. Installation of Network Controllers:
 - 1. DDC system provider and DDC system manufacturer to determine quantity and location of network controllers to satisfy requirements indicated.[**Provide minimum quantity indicated.**]
 - 2. Install controllers in a protected location that is easily accessible by operators.
 - 3. Locate top of controller within [72 inches][84 inches]<Insert dimension> of finished floor.
- F. Installation of Programmable Application Controllers:
 - 1. DDC system provider and DDC system manufacturer to determine quantity and location of programmable application controllers to satisfy requirements indicated.[**Provide minimum quantity indicated.**]
 - 2. Install controllers in a protected location that is easily accessible by operators.
 - 3. Locate top of controller within [72 inches][84 inches]<Insert dimension> of finished floor, except where dedicated controllers are installed at terminal units.
- G. Application-Specific Controllers:
 - 1. DDC system provider and DDC system manufacturer to determine quantity and location of application-specific controllers to satisfy requirements indicated.[**Provide minimum quantity indicated.**]
 - 2. For controllers not mounted directly on equipment being controlled, install controllers in a [protected]location that is easily accessible by operators.

3.15 INSTALLATION OF WIRELESS ROUTERS FOR OPERATOR INTERFACE

- A. Install wireless routers to achieve optimum performance and best possible coverage.
- B. Mount wireless routers in a protected location that is within [60 inches]<Insert requirement> of floor and easily accessible by operators.
- C. Connect wireless routers to field power supply and to UPS units if network controllers are powered through UPS units.
- D. Install wireless router with latest version of applicable software and configure wireless router with security and password protection. Create access password with not less than 12 characters consisting of letters and numbers and at least one special character. Document password in operations and maintenance manuals for reference by operators.
- E. Test and adjust wireless routers for proper operation with all types (such as, laptops, smartphones, and tablets) of wireless devices intended for use by operators.

3.16 INSTALLATION OF ENCLOSURES

- A. Install the following items in enclosures, to comply with indicated requirements:
1. Gateways.
 2. Routers.
 3. Controllers.
 4. Electrical power devices.
 5. UPS units.
 6. Relays.
 7. Accessories.
 8. Instruments.
 9. Actuators.
 10. **<Insert devices>**.
- B. Attach wall-mounted enclosures to wall using the following types of steel struts:
1. For NEMA 250 Enclosures: **[Type 1]<Insert type>**; use **[painted steel][galvanized-steel][corrosion-resistant-coated steel]** strut and hardware.
 2. For NEMA 250 Enclosures and Enclosures Located Outdoors: **[Type 4][Type 4X]<Insert type>**; use stainless steel strut and hardware.
 3. Install plastic caps on exposed cut edges of strut.
- C. Align **[top][or][bottom]** of adjacent enclosures **[of like size]**.
- D. Install floor-mounted enclosures located **[in mechanical equipment rooms]** on concrete housekeeping pads. Attach enclosure legs using **[galvanized-steel][or][stainless steel]** anchors.
- E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireways used for application are to have protection equal to NEMA 250 rating of connected enclosures.

3.17 ELECTRIC POWER CONNECTIONS

- A. Connect electrical power to DDC system products requiring electrical power connections.
- B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade to provide a fully functioning DDC system. Work is to comply with NFPA 70 and other requirements indicated.
- C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.
- D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.
- E. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems," Section 260533.16 "Boxes and Covers for Electrical Systems," and Section 260533.23 "Surface Raceways for Electrical Systems" for electrical power raceways and boxes.

3.18 INSTALLATION OF IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section

260553 "Identification for Electrical Systems" for identification products and installation.

- B. Install **[self-adhesive labels][laminated acrylic or melamine plastic signs]** with unique identification on face for each of the following:
 - 1. Server.
 - 2. Gateway.
 - 3. Router.
 - 4. Protocol analyzer.
 - 5. DDC controller.
 - 6. Enclosure.
 - 7. Electrical power device.
 - 8. UPS unit.
 - 9. Accessory.
- C. Install unique instrument identification for each instrument connected to DDC controller.
- D. Install unique identification for each control **[damper][and][valve]** actuator connected to DDC controller.
- E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.
- F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.
- G. Warning Labels and Signs:
 - 1. Permanently attach to equipment that can be automatically started by DDC control system.
 - 2. Locate where highly visible near power service entry points.

3.19 INSTALLATION OF NETWORKS

- A. Install optical fiber cable when connecting between the following network devices and when located in different buildings on campus, or when distance between devices exceeds **<Insert distance>**:
 - 1. Operator workstations.
 - 2. Operator workstations and network controllers.
 - 3. Network controllers.
 - 4. **<Insert network device>**.
- B. Install balanced twisted pair **[or optical fiber]** cable when connecting between the following network devices **[located in same building]**:
 - 1. Operator workstations.
 - 2. Operator workstations and network controllers.
 - 3. Network controllers.
 - 4. **<Insert network device>**.
- C. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:
 - 1. Gateways.
 - 2. Gateways and network controllers or programmable application controllers.

3. Routers.
4. Routers and network controllers or programmable application controllers.
5. Network controllers and programmable application controllers.
6. Programmable application controllers.
7. Programmable application controllers and application-specific controllers.
8. Application-specific controllers.
9. **<Insert network device>.**

D. Install cable in continuous raceway.

1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.20 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:

1. MAC Address:

- a. Assign and document a MAC address unique to its network for every network device.
- b. Ethernet Networks: Document MAC address assigned at its creation.
- c. MS/TP Networks: Assign from 00 to 64.

2. Network Numbering:

- a. Assign unique numbers to each new network.
- b. Provide ability for changing network number through device switches or operator interface.
- c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

3. Device Object Identifier Property Number:

- a. Assign unique device object identifier property numbers or device instances for each device network.
- b. Provide for future modification of device instance number by device switches or operator interface.
- c. LAN is to support up to 4,194,302 unique devices.

4. Device Object Name Property Text:

- a. Device object name property field to support 32 minimum printable characters.
- b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.
 - 1) Example 1: Device object name for device controlling heating water boiler plant at Building 1000 would be "Heating Water System Bldg. 1000."
 - 2) Example 2: Device object name for VAV terminal unit controller could be "VAV Unit 102."

5. Object Name Property Text for Other Than Device Objects:

- a. Object name property field is to support 32 minimum printable characters.
- b. Assign object name properties with plain-English names descriptive of application.

- 1) Example 1: "Zone 1 Temperature."
- 2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:

- a. Assign object identifier property numbers according to **[Drawings][or][tables]** indicated.
- b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented, and be unique for like object types within device.

3.21 INSTALLATION OF AIR SIGNAL PIPING AND TUBING

A. Above-Grade Air Signal Piping and Tubing Installation:

1. Material Application:

- a. Install copper tubing, except as follows:
 - 1) Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing.
 - 2) Concealed Tubing: Polyethylene tubing may be used in lieu of copper tubing when **[concealed behind accessible ceilings][and][concealed in walls and connecting wall-mounted instruments with recessed connections]**.
- b. Install copper tubing for sizes up through **[NTS 1]<Insert size>** and install galvanized-steel pipe for larger sizes, except as follows:
 - 1) Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing where exposed to view.
 - 2) Concealed Tubing: Polyethylene tubing may be used in lieu of copper tubing when **[concealed behind accessible ceilings][and][concealed in walls and connecting wall-mounted instruments with recessed connections]**.
- c. Pneumatic Tubing: Install copper tubing[, **unless other accessible materials are indicated,**] for pneumatic main and control signals to instruments including, but not limited to, the following:
 - 1) Pneumatic actuators.
 - 2) I/P transducers.
 - 3) Sensors.
 - 4) Switches.
 - 5) Transmitters.
 - 6) **<Insert instrument>**.
- d. Install copper tubing[, **unless other accessible materials are indicated,**] for air signals to instruments including, but not limited to, the following:
 - 1) Sensors.
 - 2) Switches.
 - 3) Transmitters.
 - 4) **<Insert instrument>**.
- e. Install drawn-temper copper tubing, except within **36 inches** of device terminations tubing is to be annealed-tempered copper tubing.

- f. Install compression fittings to connect copper tubing to instruments, control devices, and accessories.
 - g. Install **[barbed][or][compression]** fittings to connect polyethylene tubing to instruments, control devices, and accessories.
- 2. Routing:
 - a. Do not expose tubing in finished spaces, such as spaces with ceilings; occupied spaces, offices, and conference rooms, unless expressly approved in writing by Architect. Tubing may be exposed in areas without ceilings.
 - b. Where tubing is installed in finished occupied spaces, install the tubing in surface metal raceway with appropriate fittings only where not feasible to conceal in wall, above ceiling, or behind architectural enclosures or covers.
 - c. Install piping and tubing plumb and parallel to and at right angles with building construction.
 - d. Install multiple runs of tubing or piping in equally spaced parallel lines.
 - e. Install piping and tubing not to interfere with access to valves, equipment, duct, and equipment access doors, or obstruct personnel access and passageways of any kind.
 - f. Coordinate with other trades before installation to prevent proposed piping and tubing from interfering with pipe, duct, terminal equipment, light fixtures, conduit, and cable tray space. If changes to Shop Drawings are necessary due to field coordination, document changes on Record Drawings.
 - g. Install vibration loops in copper tubing when connecting to instruments and actuators that vibrate.
- 3. Support:
 - a. Space supports in accordance with MSS SP-58, except support spacing not to exceed **60 inches**.
 - b. Support copper tubing with copper hangers, clips, and tube trays.
 - c. Do not use tape for support or dielectric isolation.
 - d. Install supports at each change in direction and at each branch take-off.
 - e. Attached supports to building structure independent of work of other trades. Support from ducts, pipes, cable trays, and conduits is prohibited.
 - f. Attached support from building structure with threaded rods, structural shapes, or channel strut.
 - g. Install and brace supports to carry static load plus a safety margin, which will allow tubing to be serviced.
 - h. Brace supports to prevent lateral movement.
 - i. Paint steel support members that are not galvanized or zinc coated.
 - j. Support polyethylene tubing same as copper tubing.
- 4. Do not attach piping and tubing to equipment that may be removed frequently for maintenance or that may impart vibration and expansion from temperature change.
- 5. Protect exposed tubing in mechanical equipment rooms **[and similar utility spaces]** from mechanical damage within **[76 inches][84 inches][96 inches]<Insert dimension>** above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.
- 6. Joining and Makeup:
 - a. Where joining and mating dissimilar metals where galvanic action could occur, install dielectric isolation.
 - b. Install dirt leg with an isolation valve and threaded plug at each main air, connection to panel, pneumatic pilot positioner, and PRV station.
 - c. Make threaded joints for connecting to instrument equipment with connectors with a compression tubing connector on one end and threaded connection on the other end.
 - d. Make tubing bends with tube-bending tool. Hard-bends or wrinkled or flattened bends are unacceptable.

- e. Install tube fittings in accordance with manufacturer's written instructions.
 - f. Do not make tubing connections to a fitting before completing makeup of the connection.
 - g. Align tubing with fitting. Avoid springing tube into position; this may result in excessive stress on both tubing and fitting with possible resulting leaks.
 - h. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for proper connection.
 - i. Check tubing for correct diameter and wall thickness.
 - j. Cut tube ends square and deburr. Exercise care during cutting to keep tubing round.
 - k. Thread pipe on a threading machine. Ream inner edges of pipe ends, and file and grind to remove burrs.
 - l. Wrap pipe threads with single wrap of PTFE tape.
 - m. Protect piping and tubing from entrance of foreign matter.
7. Do not exceed 50 percent fill capacity where tubing is installed in conduit. Support conduit in accordance with NFPA 70 unless otherwise indicated.

B. Below-Grade Air Signal Piping and Tubing Installation:

- 1. Install tubing below-grade in a continuous Schedule 80, PVC conduit.
- 2. Do not exceed 50 percent fill capacity; minimum size **[2 inches][4 inches]<Insert size>**.
- 3. Install top of conduit at depth of at least **[24 inches][36 inches]<Insert distance>** below finished grade.
- 4. Install tubing in raceways dedicated to only tubing. Do not combine electrical conductors and tubing in raceways.

C. Identify above-grade piping and tubing as follows:

- 1. Every **50 ft.** of straight run.
- 2. At least once for each branch within **36 inches** of main tee.
- 3. At each change in direction.
- 4. Within **36 inches** of each ceiling, floor, roof, and wall penetration.
- 5. Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.
- 6. At each valve.
- 7. Mark each instrument tube connection with a number-coded identification. Each unique tube is to have same unique number at instrument connection and termination at opposite end of tube.

D. Valve Installation for Pneumatic Tubing:

- 1. Install valves full size of piping and tubing.
- 2. Install at the following locations:
 - a. At each branch.
 - b. Before and after each PRV.
 - c. Before and after each air dryer.
 - d. At each control device.
- 3. Locate valves to be readily accessible from floor.
- 4. Install needle valves for isolation and throttling applications. **[Option to install ball valves in lieu of needle valves for isolation only applications.]**

3.22 INSTALLATION OF PROCESS TUBING

- A. Install process tubing for signal to instruments in liquid and steam systems. Instruments include, but are

not limited to, the following:

1. Meters.
 2. Sensors.
 3. Switches.
 4. Transmitters.
- B. Support tubing in accordance with MSS SP-58, but at intervals no more than **60 inches** apart.
- C. Install minimum **NPS 1/2** process tubing for industrial-grade sensors, transmitters, and switches. Install bushings where required.
- D. Make smooth tubing bends with a bending tool. Flattened or wrinkled bends are unacceptable.
- E. Support tubing independent of other trades.
- F. Route tubing parallel to and at right angles to building construction.
- G. Install tubing concealed in areas with ceilings.
- H. Install dirt leg with an isolation valve and threaded plug in drain valve at each connection to a transmitter and switch.
- I. Insulate process piping and tubing connected to hot water and steam systems for personnel protection if surface temperature exceeds **120 deg F**. Only insulate piping and tubing within maintenance personnel reach from floor, platform, or catwalk.
- J. Wrap pipe threads of fitting in process tubing with service temperatures below **350 deg F** with single wrap of PTFE tape.
- K. Coat pipe threads of fittings on process tubing in services with temperatures exceeding **350 deg F** with pipe compound before being made up to reduce possibility of galling.
- L. Do not make tubing connections to a fitting before completing makeup of connection.
- M. Check tubing for correct diameter and wall thickness. Cut the tube ends square and deburred. Exercise care during cutting to keep tubing round.
- N. Do not install fittings close to a bend. Straight length of tubing, not deformed by bending, is required for proper connection.
- O. Align tubing with fitting when installed. Avoid springing tube into position.
- P. Install tubing with extreme care to keep foreign matter out of system. Plug open tubing ends to keep out dust, dirt, and moisture.
- Q. Do not attach tubing to equipment that may be removed frequently for maintenance or may impart vibration and expansion from temperature change.
- R. Protect exposed tubing in mechanical equipment rooms from inadvertent mechanical damage within [**76 inches**][**84 inches**][**96 inches**]**<Insert dimension>** above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.
- S. Below-Grade Process Tubing Installation:

1. Install tubing below-grade in a continuous Schedule 80, PVC conduit.
2. Do not exceed 50 percent fill capacity; minimum size [2 inches][4 inches]<Insert size>.
3. Install top of conduit at depth of at least [24 inches][36 inches]<Insert distance> below finished grade.
4. Install tubing in raceways dedicated to only process tubing. Do not combine electrical conductors and tubing in raceways.

T. Identify above-grade process tubing as follows:

1. Every 50 ft. of straight run.
2. At least once for each branch within 36 inches of main tee.
3. Near each change in direction.
4. Within 36 inches of each ceiling, floor, roof, and wall penetration.
5. Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.
6. Near each isolation valve.
7. Mark each instrument tube connection with a number-coded identification. Each unique tube is to have same unique number at instrument connection and termination at opposite end of tube.

U. Process Tubing Isolation Valves Installation:

1. Install valves full size of piping and tubing.
2. Install isolation valves at the following locations:
 - a. Process connection.
 - b. Inlet to each instrument including, sensors, transmitters, switches, gauges, and other control devices.
3. Locate valves to be readily accessible from floor.
4. Install needle valves for isolation and throttling applications. [Option to install ball valves in lieu of needle valves for isolation only applications.]

3.23 INSTALLATION OF CONTROL WIRE, CABLE, AND RACEWAY

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Comply with installation requirements in Section 260523 "Control-Voltage Electrical Power Cables."
2. Comply with installation requirements in Section 271313 "Communications Copper Backbone Cabling."
3. Comply with installation requirements in Section 271513 "Communications Copper Horizontal Cabling."
4. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
 - a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
5. Terminate wiring in a junction box.
 - a. Clamp cable over jacket in a junction box.

- b. Individual conductors in the stripped section of cable is to be slack between the clamping point and terminal block.
 - 6. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
 - 7. Install signal transmission components in accordance with IEEE C2, REA Form 511a, NFPA 70, and as indicated.
 - 8. Use shielded cable to transmitters.
 - 9. Use shielded cable to temperature sensors.
 - 10. Perform continuity and meager testing on wire and cable after installation.
- C. Conduit Installation:
- 1. Comply with Section 260533.13 "Conduits for Electrical Systems," Section 260533.16 "Boxes and Covers for Electrical Systems," and Section 260533.23 "Surface Raceways for Electrical Systems" for control-voltage conductors.
 - 2. Comply with Section 270528 "Pathways for Communications Systems" for balanced twisted pair cabling and optical fiber installation.

3.24 INSTALLATION OF OPTICAL FIBER CABLE SYSTEMS

- A. Comply with installation requirements in Section 271323 "Communications Optical Fiber Backbone Cabling."
- B. Comply with installation requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling."

3.25 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.
- C. Tests and Inspections: Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Testing of Air-Signal Tubing:
 - 1. Test for leaks and obstructions.
 - 2. Disconnect each pipe and tubing line before test is performed, and blowout dust, dirt, trash, condensate, and other foreign materials with compressed air. Use commercially pure compressed air or nitrogen as distributed in gas cylinders. Use of compressed air from oil-free compressor with air dryer is an acceptable alternative for test.
 - 3. After foreign matter is expelled and line is free from obstructions, plug far end of tubing run.
 - 4. Connect pressure source to near end of tubing run with needle valve between air supply and tubing run.
 - 5. Connect pressure gauge accurate to within 0.5 percent of test between shutoff needle valve and

tubing run under test.

6. For air signal tubing, apply test pressure of [1.5][2.0]<Insert value> times instrument operating pressure range. Record pressure in tubing run every 10 minutes for one hour. Allowable drop in pressure in one-hour period to not exceed [0.1]<Insert number> percent of test pressure.
7. For pneumatic system pressures above 30 psig, apply pressure of [1.1][1.5]<Insert value> times operating pressure to tubing run. Record pressure in tubing run every 10 minutes for one hour. Allowable drop in pressure in one-hour period to not exceed [1 psig]<Insert value>.
8. For pneumatic system pressures 30 psig and below, apply pressure of [1.5][2.0]<Insert value> times operating pressure to tubing run. Record pressure in tubing run every five minutes for one hour. Allowable drop in pressure in one-hour period to not exceed [0.5 psig]<Insert value>.

E. Optical Fiber Cable Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. At a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Perform testing according to test plan supplied by DDC system manufacturer. Correct defective Work or material and retest. At a minimum, final testing for cable system, including spare cable, to verify compliance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use optical fiber time-domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.26 DDC SYSTEM I/O CHECKOUT PROCEDURES

- A. Check installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
- E. For pneumatic products, verify that air supply for each product is properly installed.
- F. Control Damper Checkout:
 1. For pneumatic control dampers, verify that pressure gauges are provided in each air line connected to the damper actuator and positioner.
 2. Verify that control dampers are installed correctly for flow direction.
 3. Verify that proper blade alignment, either parallel or opposed, has been provided.
 4. Verify that damper frame attachment is properly secured and sealed.
 5. Verify that damper actuator and linkage attachment are secure.

6. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
7. Verify that damper blade travel is unobstructed.

G. Control Valve Checkout:

1. For pneumatic control valves, verify that pressure gauges are provided in each air line connected to the valve actuator and positioner.
2. Verify that control valves are installed correctly for flow direction.
3. Verify that valve body attachment is properly secured and sealed.
4. Verify that valve actuator and linkage attachment are secure.
5. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
6. Verify that valve ball, disc, or plug travel is unobstructed.
7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace valve if leaks persist.

H. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction, and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type, and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments, verify the following:
 - a. Sensing element type and proper material.
 - b. Length and insertion.

3.27 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION, AND TESTING

- A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
- B. Provide written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
- C. For each analog instrument, make three-point test of calibration for both linearity and accuracy.
- D. Equipment and procedures used for calibration to comply with instrument manufacturer's written instructions.
- E. Provide diagnostic and test equipment for calibration and adjustment.
 1. Use field testing and diagnostic instruments and equipment with an accuracy at least twice the instrument accuracy of instrument to be calibrated. For example, test and calibrate an installed instrument with accuracy of 1 percent using field testing and diagnostic instrument with accuracy of 0.5 percent or better.
- F. Calibrate each instrument in accordance with instruction manual supplied by instrument manufacturer.

- G. If after calibration the indicated performance cannot be achieved, replace out-of-tolerance instruments.
- H. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated.
- I. Analog Signals:
 - 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 - 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
- J. Digital Signals:
 - 1. Check digital signals using a jumper wire.
 - 2. Check digital signals using an ohmmeter to test for contact making or breaking.
- K. Control Dampers:
 - 1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
 - 2. Stroke pneumatic control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.
 - 3. Check and document open and close cycle times for applications with cycle time less than **[30]<Insert number>** seconds.
 - 4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- L. Control Valves:
 - 1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
 - 2. Stroke pneumatic control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.
 - 3. Check and document open and close cycle times for applications with cycle time less than **[30]<Insert number>** seconds.
 - 4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- M. Meters: Check meters at zero, 50, and 100 percent of Project design values.
- N. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- O. Switches: Calibrate switches to make or break contact at set points indicated.
- P. Transmitters:
 - 1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
 - 2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.28 DDC SYSTEM CONTROLLER CHECKOUT

- A. Verify power supply.
 - 1. Verify voltage, phase, and hertz.
 - 2. Verify that protection from power surges is installed and functioning.
 - 3. Verify that ground fault protection is installed.
 - 4. If applicable, verify if connected to UPS unit.
 - 5. If applicable, verify if connected to backup power source.
 - 6. If applicable, verify that power conditioning units are installed.
- B. Verify that wire and cabling are properly secured to terminals and labeled with unique identification.
- C. Verify that spare I/O capacity is provided.

3.29 DDC CONTROLLER I/O CONTROL LOOP TESTS

- A. Testing:
 - 1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
 - 2. Test every I/O point throughout its full operating range.
 - 3. Test every control loop to verify that operation is stable and accurate.
 - 4. Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
 - 5. Test and adjust every control loop for proper operation according to sequence of operation.
 - 6. Test software and hardware interlocks for proper operation. Correct deficiencies.
 - 7. Operate each analog point at the following:
 - a. Upper quarter of range.
 - b. Lower quarter of range.
 - c. At midpoint of range.
 - 8. Exercise each binary point.
 - 9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller, and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller, and at field instrument must match.
 - 10. Prepare and submit report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

3.30 DDC SYSTEM VALIDATION TESTS

- A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.
- B. After **[review][approval]** of Pretest Checklist and Test Plan, execute all tests and procedures indicated in plan.
- C. After testing is complete, submit completed Pretest Checklist.
- D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.
8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable, and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting, and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power[**and loss of signal**].
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power[**and loss of signal**].
18. Meter, sensor, and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphics are created.
26. Record Drawings are completed.
27. **<Insert additional requirements>.**

E. Test Plan:

1. Prepare and submit validation Test Plan including test procedures for performance validation tests.
2. Address all specified functions of DDC system and sequences of operation in Test Plan.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include Test Checklist to be used to check and initial that each test has been successfully completed.
6. Submit Test Plan documentation [10][20]**<Insert number>** business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.
 - a. Verify analog I/O points at operating value.
 - b. Make adjustments to out-of-tolerance I/O points.
 - 1) Identify I/O points for future reference.
 - 2) Simulate abnormal conditions to demonstrate proper function of safety devices.
 - 3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.
 3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
 4. 24 hours after initial validation test, do as follows:
 - a. Re-check I/O points that required corrections during initial test.
 - b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
 5. 24 Hours after second validation test, do as follows:
 - a. Re-check I/O points that required corrections during second test.
 - b. Continue validation testing until I/O point is normal on two consecutive tests.
 6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
 7. After validation testing is complete, prepare and submit report indicating results of testing. For all I/O points that required correction, indicate how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.
- G. DDC System Response Time Test:
1. Simulate HLC.
 - a. Heavy load to be occurrence of **[50]<Insert number>** percent of total connected binary COV, one-half of which represents "alarm" condition, and **[50]<Insert number>** percent of total connected analog COV, one-half of which represents "alarm" condition, that are initiated simultaneously on a one-time basis.
 2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
 3. Measure with timer having at least 0.1-second resolution and 0.01 percent accuracy.
 4. Purpose of test is to demonstrate DDC system, as follows:
 - a. Reaction to COV and alarm conditions during HLC.
 - b. Ability to update DDC system database during HLC.
 5. Passing test is contingent on the following:
 - a. Alarm reporting at printer beginning no more than **[two]<Insert number>** seconds after initiation (time zero) of HLC.
 - b. All alarms, both binary and analog, are reported and printed; none are lost.
 - c. Compliance with response times specified.
 6. Prepare and submit report documenting HLC tested and results of test including time stamp and print out of all alarms.
- H. DDC System Network Bandwidth Test:
1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
 2. To pass, none of DDC system networks are to use more than 70 percent of available bandwidth under normal and HLC operation.



3.31 VERIFICATION OF DDC SYSTEM WIRELESS NETWORK

- A. DDC system Installer is to design wireless DDC system networks to comply with performance requirements indicated.
- B. Verify wireless network performance through field testing and document results in a field test report.
- C. Testing and verification of all wireless devices to include, but not be limited to, the following:
 - 1. Speed.
 - 2. Online status.
 - 3. Signal strength.

3.32 FINAL REVIEW

- A. Submit written request to Architect **[Owner][Commissioning Agent][and][Construction Manager]** when DDC system is ready for final review. State the following:
 - 1. DDC system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
 - 2. DDC system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
 - 3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
 - 4. DDC system is complete and ready for final review.
 - 5. **<Insert additional requirements>**.
- B. Upon receipt of written request for final review, **[Architect][Owner][Commissioning Agent][and][Construction Manager]** to start review within **[xx business days][reasonable period]** and upon completion issue field report(s) documenting observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in reviewer's field report(s) and submit second written request after all deficiencies have been corrected. Repeat process until no deficiencies are reported.
- D. Compensation for Subsequent Reviews: Should more than **[two]<Insert number>** reviews be required, DDC system manufacturer and Installer to compensate entity/entities performing reviews for total costs (labor and expenses) associated with subsequent reviews. Estimated cost of each subsequent review to be submitted and approved by DDC system manufacturer and Installer before review.
- E. Prepare and submit closeout submittals **[and begin procedures indicated in "Extended Operation Test" Article]** when no deficiencies are reported.
- F. Part of DDC system final review to include demonstration to parties participating in final review.
 - 1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
 - 2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
 - 3. Demonstration to include, but not be limited to, the following:
 - a. Accuracy and calibration of **[10][20]<Insert number>** I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers

- until total I/O points being reviewed that satisfy requirements equals quantity indicated.
- b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to [10][20]<Insert number> I/O points to be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
- c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
- d. Operation of randomly selected dampers and valves in normal-on, normal-off, and failed positions.
- e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
- f. Trends, summaries, logs, and reports set up for Project.
- g. For up to [three]<Insert number> HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
- h. Software's ability to communicate with controllers, operator workstations, and uploading and downloading of control programs.
- i. Software's ability to edit control programs offline.
- j. Data entry to show Project-specific customizing capability including parameter changes.
- k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
- l. Execution of digital and analog commands in graphic mode.
- m. Spreadsheet and curve plot software and its integration with database.
- n. Online user guide and help functions.
- o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
- p. System speed of response compared to requirements indicated.
- q. For Each Controller: Applies to [network][and][programmable application] controllers.
 - 1) Memory: Programmed data, parameters, trend, and alarm history collected during normal operation are not to be lost during power failure.
 - 2) Operator Interface: Ability to connect directly to each type of digital controller with portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
 - 3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
 - 4) Electric Power: Ability to disconnect any controller safely from its power source.
 - 5) Wiring Labels: Match control drawings.
 - 6) Network Communication: Ability to locate controller's location on network and communication architecture matches Shop Drawings.
 - 7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.
- r. For Each Operator Workstation:
 - 1) I/O points lists agree with naming conventions.
 - 2) Graphics are complete.
 - 3) UPS unit, if applicable, operates.
- s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management.[Use ASHRAE 135 protocol analyzer to help identify devices, view

network traffic, and verify interoperability.] Requirements must be met even if only one manufacturer's equipment is installed.

- 1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
- 2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.
- 3) Set-Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated. **[Modifications are made with messages and write services initiated by operator using workstation graphics, or by completing a field in menu with instructional text.]**
- 4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
- 5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
- 6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
- 7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
- 8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
- 9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
- 10) Device and Network Management:
 - a) Display of network device status.
 - b) Display of BACnet object information.
 - c) Silencing devices transmitting erroneous data.
 - d) Time synchronization.
 - e) Remote device re-initialization.
 - f) Backup and restore network device programming and master database(s).
 - g) Configuration management of routers.

t. **<Insert additional requirements>.**

3.33 EXTENDED OPERATION TEST

- A. Operate DDC system for operating period of [14][21][28]**<Insert number>** consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.
- B. Provide operator familiar with DDC system installed to man an operator workstation **[while on-site]** during eight hours of each normal business day occurring during operating period.
- C. During operating period, DDC system to demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.
 1. Correct defects of hardware and software when they occur.
- D. Definition of Failures and Downtime during Operating Period:

1. Failed I/O point constituting downtime is I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
 2. Downtime is when any I/O point in DDC system is unable to fulfill its required function.
 3. Calculate downtime as elapsed time between detected point failure as confirmed by operator, and time point is restored to service.
 4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation is to be 0.5 hours.
 5. Log downtime in hours to nearest 0.1 hour.
 6. Power outages do not count as downtime, but do suspend test hours unless systems are provided with UPS and served through a backup power source.
 7. Hardware or software failures caused by power outages do count as downtime.
- E. During operating period, log downtime and operational problems are encountered.
1. Identify source of problem.
 2. Provide written description of corrective action taken.
 3. Record duration of downtime.
 4. Maintain log showing the following:
 - a. Time of occurrence.
 - b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
 - c. Downtime for each failed I/O point.
 - d. Running total of downtime and total time of I/O point after each problem has been restored.
 5. Make log available to Owner for review at any time.
- F. For DDC system to pass extended operation test, total downtime is limited to [1][2]<Insert number> percent of total point-hours during operating period.
1. If DDC system testing results fail to comply with minimum requirements of passing at end of operating period indicated, extend operating period one consecutive day at a time until DDC system passes requirement.
- G. Base evaluation of DDC system passing test on the following calculation:
1. Count downtime on point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.
 2. One point-hour of downtime is one I/O point down for one hour. For example, three I/O points down for five hours is total of 15 point-hours of downtime. Four points down for one-half hour is two point-hours of downtime.
 3. Example Calculation: Maximum allowable downtime for 30-day test for DDC system with 1000 total I/O points (combined analog and binary) and passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.
- H. Prepare test and inspection reports.
- 3.34 ADJUSTING
- A. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.35 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes **[three][six][nine][12]<Insert number>** months' full maintenance by DDC system manufacturer's authorized service representative. Include **[monthly][quarterly][semiannual][annual]** preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration, and adjusting as required for proper operation. Use only manufacturer's authorized replacement parts and supplies.

3.36 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, verify that service agreement includes software support for **[one][two]<Insert number>** year(s).
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within **[one][two]<Insert number>** year(s) from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.
1. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.37 DEMONSTRATION

- A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.
- B. Extent of Training:
1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:
- a. Provide not less than **[five][10][15]<Insert number>** days of training total.
- b. Stagger training over multiple training classes to accommodate Owner's requirements. All training to occur before end of warranty period.
- c. Break down total days of training into not more than **[two][three][four]<Insert number>** separate training classes.
- d. Schedule training so each training class is not less than **[one][two][three]<Insert number>** consecutive day(s).
- C. Training Schedule:
1. Schedule training with Owner **[20]<Insert number>** business days before expected Substantial Completion.
2. Schedule training to provide Owner with at least **[10][15][20]<Insert number>** business days of notice in advance of training.
3. Training to occur within normal business hours at mutually agreed on time. Unless otherwise agreed to, training to occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session to

be split in half with [15][30]<Insert number>-minute break between sessions. Morning and afternoon sessions to be separated by [30][60]<Insert number>-minute lunch period. Training, including breaks and excluding lunch period, are not to exceed [eight]<Insert number> hours per day.

4. Provide staggered training schedule as requested by Owner.

D. Training Attendee List and Sign-in Sheet:

1. Request from Owner in advance of training a proposed attendee list with name, phone number, and email address.
2. Provide preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Include preprinted sign-in sheet with training session number, date and time, instructor name, phone number, email address, and brief description of content to be covered during session. List attendees with columns for name, phone number, and email address and a column for attendee signature or initials.
4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5. At end of each training day, send Owner an email with attachment of scanned copy (PDF) of circulated sign-in sheet for each session. **[Indicate which attendees, if any, joined for only part of training sessions].**

E. Training Attendee Headcount:

1. Plan in advance of training for [two][three][five]<Insert number> attendees.
2. Make allowance for Owner to add up to [one][two]<Insert number> attendee(s) at time of training.
3. Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

F. Training Attendee Prior Knowledge: For guidance in planning required training and instruction, assume attendees have the following:

1. **[High school][High school and technical school][High school and four-year college]<Insert level>** education and degree.
2. **[Basic][Intermediate][Advanced]** user knowledge of computers and office applications.
3. **[Basic][Intermediate][Advanced]** knowledge of HVAC systems.
4. **[Basic][Intermediate][Advanced]** knowledge of DDC systems.
5. **[Basic][Intermediate][Advanced]** knowledge of DDC system and products installed.

G. Attendee Training Manuals:

1. Provide each attendee with color hard copy of all training materials and visual presentations.
2. Organize hard-copy materials in three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes DVD or flash drive with PDF copy of all hard-copy materials.

H. Instructor Requirements:

1. One or multiple qualified instructors, as required, to provide training.
2. Use instructors who have provided not less than [five]<Insert number> years of instructional training on not less than [five]<Insert number> past projects with similar DDC system scope and complexity to DDC system installed.

I. Organization of Training Sessions:

1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
 - a. Daily operators.
 - b. Advanced operators.
 - c. System managers and administrators.
2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions to ensure DDC system security.

J. Training Outline:

1. Submit training outline for Owner review at least [10]<Insert number> business day before scheduling training.
2. Include in outline a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session, and synopses for each lesson planned.

K. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
2. Provide training materials, projector, and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. Include on-site training with regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
5. Use operator workstation that is to be used with DDC system in the training. If operator workstations are unavailable, provide temporary workstation to convey training content.

L. Off-Site Training:

1. Provide conditioned training rooms and workspace with ample tables desks or tables, chairs, power, and data connectivity for each attendee.
2. Provide capability to remotely access to Project DDC system for use in training.
3. Provide operator workstation for use by each attendee.

M. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm, and each unique optimization routine.
5. Operating operator workstations, printers, and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports, and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.

13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
18. Executing digital and analog commands in graphic mode.
19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
 - a. Operation of HVAC equipment in normal-off, normal-on, and failed conditions while observing individual equipment, dampers, and valves for correct position under each condition.
 - b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
 - c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles, and other modes of operation indicated.
 - d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
 - e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
 - f. Each control loop responds to set-point adjustment and stabilizes within time period indicated.
 - g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.
 - h. **<Insert requirement>**.

N. Training Content for Advanced Operators:

1. Making and changing workstation graphics.
2. Creating, deleting, and modifying alarms including annunciation and routing.
3. Creating, deleting, and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
4. Creating, deleting, and modifying reports.
5. Creating, deleting, and modifying points.
6. Creating, deleting, and modifying programming including ability to edit control programs offline.
7. Creating, deleting, and modifying system graphics and other types of displays.
8. Adding DDC controllers and other network communication devices such as gateways and routers.
9. Adding operator workstations.
10. Performing DDC system checkout and diagnostic procedures.
11. Performing DDC controllers operation and maintenance procedures.
12. Performing operator workstation operation and maintenance procedures.
13. Configuring DDC system hardware including controllers, workstations, communication devices,

and I/O points.

14. Maintaining, calibrating, troubleshooting, diagnosing, and repairing hardware.
15. Adjusting, calibrating, and replacing DDC system components.
16. **<Insert requirement>**.

O. Training Content for System Managers and Administrators:

1. DDC system software maintenance and backups.
2. Uploading, downloading, and offline archiving of all DDC system software and databases.
3. Interface with Project-specific, third-party operator software.
4. Understanding password and security procedures.
5. Adding new operators and making modifications to existing operators.
6. Operator password assignments and modification.
7. Operator authority assignment and modification.
8. Workstation data segregation and modification.
9. **<Insert requirement>**.

P. Video of Training Sessions:

1. Provide digital video and audio recording of each training session. Create separate recording file for each session.
2. Stamp each recording file with training session number, session name, and date.
3. Provide Owner with **[two]<Insert number>** copies of digital files on cloud and flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION 23 09 23 00



SECTION 23 09 23 00A - LEAK DETECTION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Leak-detection switches.
2. Multi-zone leak-detection monitoring controllers.

B. Related Requirements:

1. Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Operating characteristics, electrical characteristics, and furnished accessories indicating control signal, default control signal with loss of power, and electrical power requirements.
2. Product description with complete technical data and product specification sheets.
3. Installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: To include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 LEAK-DETECTION SWITCHES

A. Point-Type, Leak-Detection Switches:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. **[RectorSeal HVAC; a CSW Industrials Company]**
 - b. **[Veris Industries]**
 - c. **[Vertiv Co.]**
 - d. **[W.E. Anderson; a division of Dwyer Instruments, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[RectorSeal HVAC; a CSW Industrials Company]**
 - b. **[Veris Industries]**
 - c. **[Vertiv Co.]**
 - d. **[W.E. Anderson; a division of Dwyer Instruments, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain point-type, leak-detection switches from single manufacturer.
 4. Features:
 - a. Alarms: **[Audible][and][visual]** alarm with relay output for remote indication.
 - b. Operation: Alarm activation based on detection of liquid by change in resistance.
 5. Performance:
 - a. Field Power: 24 V ac or dc.
 - b. Service: **[Water][or][conductive liquid as indicated]<Insert service>**.
 - c. Temperature Limits: **[32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.
 - d. Sensing Height: Adjustable.
 6. Construction:
 - a. Electric Connection: **[Cable][Plug-in connector][or][screw terminals]**.
 - b. Enclosure: **[Acrylic, ABS plastic][or][painted metal]**.
 - c. Switch Type: **[DPDT][SPDT][or][SPST]** relay.
- B. Cable-Type, Leak-Detection Switches:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Veris Industries]**
 - b. **[Vertiv Co.]**
 - c. **[W.E. Anderson; a division of Dwyer Instruments, Inc.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Veris Industries]**
 - b. **[Vertiv Co.]**

- c. [W.E. Anderson; a division of Dwyer Instruments, Inc.]
 - d. <Insert manufacturer's name>
- 3. Source Limitations: Obtain cable-type, leak-detection switches from single manufacturer.
- 4. Control Module Features:
 - a. Power and alarm LEDs.
 - b. Alarm test switch.
 - c. Continuous cable integrity self-check.
- 5. Performance:
 - a. Service: Water or other conductive liquid.
 - b. Switch Type: DPDT.
 - c. Electric Connection: Screw terminals.
 - d. Conduit Connection: **0.5 inch (13 mm)**.
- 6. Construction:
 - a. Control Module Enclosure: Painted metal.
 - b. Cable: Hydrophobic.
 - c. Cable Length:
 - 1) As required by application.
 - 2) Standard Cable Lengths: [5 ft. (1500 mm)][10 ft. (3 m)][15 ft. (4.5 m)][20 ft. (6 m)][25 ft. (7.5 m)][30 ft. (9 m)][40 ft. (12 m)][50 ft. (15 m)][100 ft. (30 m)]<Insert length>.
 - 3) Field Extendable: Cable with connector on each end for field extension.
 - d. NRTL Listing: NRTL listed for application where cable is installed in air plenums.
- 7. Field Power: 24 V ac or 24 to 30 V dc unless otherwise required by application.
- 8. Non-sensing Cable: Non-sensing cable may be used to extend sensing cable length in areas where sensing is not required. Non-sensing cable is not to affect performance or accuracy of readings.
- 9. Accessories: Cable cross and tee cable connectors, end connectors, and attachment clips.

2.2 MULTI-ZONE LEAK-DETECTION MONITORING CONTROLLERS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. [Veris Industries]
 - 2. [Vertiv Co.]
 - 3. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. [Veris Industries]
 - 2. [Vertiv Co.]
 - 3. <Insert manufacturer's name>

- C. Source Limitations: Obtain all multi-zone leak-detection monitoring controllers from single manufacturer.



- D. Description: Operation as stand-alone device with operator configuring, monitoring, locating, and acknowledging leaks locally, or through connection to building control network and access through internet interface, which can display location where the alarm occurred.
- E. Performance:
1. Altitude: Suitable for Project site altitude.
 2. Cable Length, Maximum: **[10,000 ft. (3000 m)]<Insert length>**.
 3. Cable Length, Minimum: **[30 ft. (9 m)]<Insert length>**.
 4. Detection Accuracy: Within **[2 ft. (600 mm) plus or minus 0.5]<Insert number>** percent of cable length.
 5. Detection Repeatability: Within **[2 ft. (600 mm) plus or minus 0.25]<Insert number>** percent of cable length.
 6. Detection Response Time: Adjustable between **[5 and 900]<Insert range>** seconds, in **[5]<Insert value>** -second intervals.
 7. Relative Humidity: 5 to 95 percent, noncondensing.
 8. Temperature: **[32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.
 9. Zones: Monitoring of up to **[100]<Insert quantity>** separate zones.
- F. Enclosure: NEMA 250, Type 1.
- G. Features:
1. Alarm Notifications:
 - a. Local Audible Alarm: **[85]<Insert value>** dBA at **[2 ft. (600 mm)]<Insert distance>** with silence feature.
 - b. Local visual alarms through display.
 - c. Remote alarm notification through interface with building control system.
 - d. E-mail alarm notifications.
 2. Display: Color, backlit, LCD screen.
 3. Logs:
 - a. Event Log: Last **[1000]<Insert number>** events.
 - b. Trend Logs: Cable current level for each of last **[365]<Insert number>** days.
 4. Password Protection: Password-protected local and remote access to change configuration, but not to view operating status.
- H. Remote Control Interface:
1. Hardwired Analog Points: 4 to 20 mA.
 2. Hardwired Digital Points:
 - a. Leak Detection: **[Two]<Insert quantity>** zones.
 - b. Cable Break: **[Two]<Insert quantity>** zones.
 - c. Maintenance: One zone.
 3. Serial Communications:
 - a. RS-485: **[Modbus RTU][BACnet MS/TP]<Insert protocol>**.
 - b. Ethernet: **[Modbus TCP/IP]<Insert protocol>**.



PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 LEAK-DETECTION INSTRUMENT APPLICATION

- A. Leak-Detection Switches (Point Type): **<Insert application>**.
- B. Leak-Detection Switches (Cable Type): **<Insert application>**.
- C. Multi-Zone Leak-Detection Monitoring Controller: **<Insert application>**.

3.3 INSTALLATION, GENERAL

- A. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.
- B. Fastening Hardware:
 - 1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force, or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- C. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.4 INSTALLATION OF LEAK-DETECTION SWITCHES

- A. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent movement.
- B. Fasten cable-type leak detection product to floor or supporting substrate using accessory clips furnished with product or a comparable product if furnished separately. Secure clip to floor and cable according to cable installation instructions.

3.5 ELECTRICAL POWER CONNECTIONS

- A. Install electrical power to field-mounted control devices requiring electrical power.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and



Cables" and Section 260523 "Control-Voltage Electrical Power Cables."

- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA/NEIS 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.6 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.7 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire and cable is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification[**and on face of ceiling directly below instruments concealed above ceilings**].

3.8 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.9 CHECKOUT PROCEDURES

- A. Check installed products before continuity tests and calibration.
- B. Check instruments for proper location and accessibility.

- C. Check instruments for proper installation for applicable considerations that impact performance.
- D. Apply test fluid to floor or substrate to check proper switch operation. Test fluid is to be the same as for operation.
 - 1. For cable-type leak detectors, check multiple locations across cable length. Number of locations will increase with length of cable.
 - a. Up to **20 ft. (6 m)**: **[Two]**<Insert quantity>, equally spaced.
 - b. Up to **50 ft. (3 m)**: **[Four]**<Insert quantity>, equally spaced.
 - c. Up to **200 ft. (60 m)**: **[Six]**<Insert quantity>, equally spaced.
 - d. Up to **1000 ft. (300 m)**: **[Eight]**<Insert quantity>, equally spaced.
 - e. <Insert test requirements>.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. Equipment and procedures used for calibration are to meet instrument manufacturer's written instructions.
 - 4. Provide diagnostic and test equipment for calibration and adjustment.
 - 5. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
 - 6. If after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
 - 7. Comply with field-testing requirements and procedures indicated by ASHRAE's Guideline 11 in the absence of specific requirements, and to supplement requirements indicated.
- B. Digital Signals:
 - 1. Check digital signals using a jumper wire.
 - 2. Check digital signals using an ohmmeter to test for contact.
- C. Switches: Calibrate switches that are adjustable to make or break contact at set points indicated.

3.11 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

END OF SECTION 23 09 23 00A



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 09 23 00B - POSITION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Position limit switches.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include operating characteristics, electrical characteristics, and furnished accessories indicating default control signal with loss of power and electrical power requirements.
2. Include product description with complete technical data and product specification sheets.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Reports: For position instruments.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A.** Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 POSITION LIMIT SWITCHES

- A.** Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be**

incorporated into the Work include, but are not limited to, the following]:

1. [Eaton; Cutler Hammer]
 2. [Honeywell International Inc.]
 3. [OMRON Corporation]
 4. [Siemens Industry, Inc., Building Technologies Division]
 5. [Square D; Schneider Electric USA]
 6. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Eaton; Cutler Hammer]
 2. [Honeywell International Inc.]
 3. [OMRON Corporation]
 4. [Siemens Industry, Inc., Building Technologies Division]
 5. [Square D; Schneider Electric USA]
 6. <Insert manufacturer's name>
- C. Source Limitations: Obtain position limit switches from single manufacturer.
- D. Description: Select type of actuating head (plunger, roller lever, or rod) to suit application.
- E. Performance:
1. Life Expectancy: Not less than [5][10][30]<Insert value> million mechanical operations and [50,000][100,000][750,000][10 million]<Insert value> electrical operations.
 2. Operating Frequency: [300]<Insert value> mechanical operations per minute and [30]<Insert value> electrical operations per minute.
 3. Voltage: 125, 250, 480, and 600 V ac or 8, 12, 14, 24, 30, 48, 125, and 250 V dc, as required by application.
 4. Current Rating: As required by application.
 5. Temperature Rise: [90 deg F (50 deg C)]<Insert temperature rise>.
 6. Ambient Temperature: [14 to 175 deg F (Minus 10 to 79 deg C)][Minus 20 to 185 deg F (Minus 29 to 85 deg C)]<Insert temperature range>.
 7. Ambient Relative Humidity: [35 to 95]<Insert relative humidity range> percent.
- F. Construction:
1. Enclosure Material: Metal with corrosion-resistant finish[or plastic].
 2. NEMA 250, [Type 1][Type 3][Type 4][Type 4X][or][Type 12]<Insert type> enclosure, as required by application
 3. Switch Type: SPDT or DPDT, as required by application.
 4. Status Indicator: Status indicator integral to switch. Field switchable to light when contacts are actuated and operating, or contacts are free and not operating.
 5. Electrical Connection: Screw or plug-in terminals.
 6. Conduit Connection: 1/2 inch NPT (16 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for

installation tolerances and other conditions affecting performance of the Work.

- B. Examine roughing-in for instruments installed to verify actual locations of connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to **[seismic][or][external]** loads.
- C. Fastening Hardware:
 - 1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- D. Install products in locations that are accessible and that permit maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- E. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they are subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments.
 - 3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 - 4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 INSTALLATION OF POSITION INSTRUMENTS

- A. Mounting Location:
 - 1. Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, and conduit to final location.
 - 2. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.



3.4 ELECTRICAL CONNECTIONS

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic sign, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic sign with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.



3.8 CHECKOUT PROCEDURES

- A. Check installed products before continuity tests and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation that impacts performance.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Digital Signals:
 - 1. Check digital signals using a jumper wire.
 - 2. Check digital signals using an ohmmeter to test for contact.
- B. Switches: Calibrate switches to make or break contact at set points indicated.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to evaluate position instruments and perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections: Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Operational Test: After installing position instruments, and after electrical circuitry has been energized, start units to confirm proper operation.
 - 2. Test and adjust position instruments. Replace damaged and malfunctioning instruments.
- D. Position instruments will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.11 ADJUSTING

- A. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting position instruments to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.
 - 1. Verify operation at outer limits.

3.12 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes **[three][six][nine][12]** months' full maintenance by **[skilled employees of systems and equipment Installer][manufacturer's authorized service representative]**. Include **[monthly][quarterly][semiannual][annual]** preventive maintenance, repair or replacement of worn or



defective components, lubrication, cleaning, and adjusting as required for proper <Insert equipment> operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

3.13 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for direct-digital control systems specified in Section 230923 "Direct-Digital Control (DDC) System for HVAC."
- B. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain position instruments.
- C. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- D. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 09 23 00B



SECTION 23 09 23 00C - SEQUENCE OF OPERATIONS FOR HVAC DDC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes control sequences for DDC for HVAC systems, subsystems, and equipment.
- B. Related Requirements:
 - 1. Section 230923 "DDC Systems for HVAC" for control equipment.

1.2 DEFINITIONS

- A. Analog Output: Proportional output signal (zero- to 10-V dc, 4 to 20 mA).
- B. Binary Output: On/off output signal or contact closure.
- C. DDC: Direct digital control.
- D. Digital Output: Data output that must be interpreted digitally.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. An instrumentation list for each controlled system. Label each element of the controlled system in table format. Show, in the table element name, type of device, manufacturer, model number, and control device product data sheet number.
 - 2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.
- B. Shop Drawings:
 - 1. Riser diagrams showing control network layout, communication protocol, and wire types.
 - 2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
 - 3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.4 HEATING CONTROL SEQUENCES

- A. Control Circulating Pump(s):
 - 1. Input Device:
 - a. Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]<Insert device>.**

- b. Location: **[Outdoor-air][Room]<Insert location>**.
- c. Transference: DDC controller.

2. Output Device:

- a. Device: Command to electric relay.
- b. Location: Motor controller.
- c. Transference: Starter relay.

3. Action:

- a. Energize pump(s) at outdoor-air temperatures below **[65 deg F (18 deg C)]<Insert temperature>**.
- b. Energize pump(s) at room temperatures below **[72 deg F (22 deg C)]<Insert temperature>**.
- c. Enable **[additional circulating pump(s)][, alternate pump(s)][, heating-water supply temperature control][and][, heating-water supply temperature reset]** control sequences.

B. Additional Circulating Pump(s):

1. Input Device:

- a. Device: Liquid pressure differential **[switch][transmitter]**.
- b. Location: Between the primary supply and return piping.
- c. Transference: DDC controller.

2. Output Device:

- a. Device: Binary output.
- b. Location: Motor controller.
- c. Transference: Starter relay.

3. Action:

- a. Energize pump(s) and maintain operation when differential pressure drops below **[30]<Insert number>** percent of specified pump head.
- b. Energize pump(s) and maintain operation when differential pressure drops below **<Insert pressure differential in psig (kPa)>** of specified pump head.

C. Circulating Pump(s) Failure Alarm:

1. Input Device:

- a. Device: Liquid pressure differential **[switch][transmitter]**.
- b. Location: Between the primary supply and return piping.
- c. Transference: DDC controller.

2. Output Device:

- a. Device: DDC controller.
- b. Transference: Operator's workstation.

3. Action:

- a. Signal alarm condition, no pressure differential between supply and return piping.
- D. Alternate Pump(s):
 - 1. Input:
 - a. Device: DDC controller.
 - b. Location: Software, **<Insert software definition>**.
 - c. Transference: Software.
 - 2. Output Device:
 - a. Device: DDC controller.
 - b. Location: Motor controller.
 - c. Transference: Motor-controller relay.
 - 3. Action: Operate pump(s) on lead-lag, alternating each startup.
 - 4. Action: Operate pump(s) on lead-lag, alternating on **<Insert value>** run hours.
- E. Control Circulating Pump(s) Speed:
 - 1. Input Device:
 - a. Device: Liquid pressure differential transmitter.
 - b. Location: Heating supply and return piping.
 - c. Transference: DDC controller.
 - 2. Output Device:
 - a. Device: Analog command.
 - b. Location: Motor controller.
 - c. Transference: Variable-frequency motor controller.
 - 3. Action:
 - a. Control pump speed to maintain pressure differential of **<Insert psig (kPa)>**.
- F. Heating-Water Supply Temperature Control:
 - 1. Input:
 - a. Device: **[Liquid temperature sensor][or][liquid temperature sensor with liquid temperature transmitter]**.
 - b. Location: Heating-water supply.
 - c. Transference: DDC controller.
 - 2. Output:
 - a. Device: Control-valve actuator.
 - b. Location: Heating-water supply.
 - c. Transference: Control-valve actuator.
 - 3. Action:
 - a. Modulate control valve to maintain heating-water supply temperature.

- b. Reset heating-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:
 - 1) [195 deg F (90 deg C)]<Insert highest heating temperature> heating water when outdoor-air temperature is [minus 30 deg F (minus 35 deg C)]<Insert lowest outdoor-air temperature>.
 - 2) [130 deg F (54 deg C)]<Insert lowest heating temperature> heating water when outdoor-air temperature is 75 deg F (24 deg C).

G. Heating-Water Supply Temperature Reset:

- 1. Input:
 - a. Device: [Liquid temperature sensor][Liquid temperature sensor with liquid temperature transmitter].
 - b. Location: Outdoor-air and heating-water supply.
 - c. Transference: DDC controller.
- 2. Output:
 - a. Device: DDC controller to boiler controls.
 - b. Location: Local panel.
 - c. Transference: Boiler control panel.
- 3. Action:
 - a. Reset heating-water supply temperature in response to greatest heating demand to maintain at least one cooling control valve 90 percent open.
 - b. Reset heating-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:
 - 1) [195 deg F (90 deg C)]<Insert highest heating temperature> heating water when outdoor-air temperature is [minus 30 deg F (minus 35 deg C)]<Insert lowest outdoor-air temperature>.
 - 2) [130 deg F (54 deg C)]<Insert lowest heating temperature> heating water when outdoor-air temperature is [75 deg F (24 deg C)]<Insert highest outdoor-air temperature>.
 - 3) [150 deg F (65 deg C)]<Insert temperature> minimum heating-water temperature.

H. Indicate the following on the operator's workstation display terminal:

- 1. DDC system graphic.
- 2. DDC system status, on-off.
- 3. Outdoor-air temperature.
- 4. Room temperature.
- 5. Circulating pump(s) on-off status (enabled or disabled).
- 6. Circulating pump(s) on-off indication (operating or not operating).
- 7. Additional circulating pump(s) pressure differential.
- 8. Additional circulating pump(s) pressure differential set point.
- 9. Additional circulating pump(s) on-off indication (operating or not operating).
- 10. Circulating pump(s) alarm pressure differential.
- 11. Circulating pump(s) alarm pressure differential set point.
- 12. Alarm (circulating pump(s) failure).
- 13. Circulating pump(s) speed pressure differential.
- 14. Circulating pump(s) speed pressure differential set point.

15. Circulating pump(s) speed.
16. Heating-water supply temperature.
17. Heating-water return temperature.
18. Heating-water control-valve position.
19. Heating-water supply temperature set point.
20. Heating-water control-point output valve.

1.5 CENTRAL CHILLED-WATER SYSTEM SEQUENCES

A. Central Chilled-Water System Time Schedule:

1. Occupied Time Schedule:

a. Input:

- 1) Device: DDC controller.
- 2) Location: Time schedule.
- 3) Transference: DDC controller.

b. Output:

- 1) Device: DDC controller.

c. Action:

- 1) Enable startup, initiation, and control.
- 2) Energize condenser-water pumps on occupied/unoccupied cycle.
- 3) Energize condenser-water pumps on day/night cycle.
- 4) After chilled-water system shutdown, operate pump(s) for an additional [**3 minutes**]<Insert time>.

2. Display:

a. Time and time schedule.

B. Start and Stop Condenser-Water Pump(s):

1. Enable:

a. Input:

- 1) Device: [**Level**][**Liquid pressure**] switch.
- 2) Location: [**Cooling tower sump**][**Pump suction**].

b. Output:

- 1) Device: Hard wired.
- 2) Location: Motor controller.
- 3) Transference: Motor-controller relay.

c. Action: Confirm adequate water level [**in cooling-tower sump**][**at pump suction**] and energize pump(s).

2. Enable:

- a. Input:
 - 1) Device: **[Level transmitter][or][liquid pressure transmitter]**.
 - 2) Location: **[Cooling tower sump][Pump suction]**.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Binary output.
 - 2) Location: Motor controller.
 - 3) Transference: Motor-controller relay.
 - c. Action: Confirm adequate water level **[in cooling-tower sump][at pump suction]** at pressures above **<Insert psig (kPa)>** and energize pump(s).
3. Enable:
- a. Input:
 - 1) Device: DDC controller outdoor-air temperature.
 - 2) Location: Outdoors.
 - 3) Transference: Binary output.
 - b. Output:
 - 1) Device: Hard wired.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Action: Confirm outdoor-air temperature is above **[50 deg F (10 deg C)]<Insert temperature>** and energize pump(s).
4. Enable:
- a. Input:
 - 1) Device: DDC controller.
 - 2) Location: Software demand.
 - 3) Transference: Binary output.
 - b. Output:
 - 1) Device: Hard wired.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Action: Confirm cooling demand from ventilation system(s) and energize pump(s).
5. Display:
- a. Low-level cooling-tower sump alarm.
 - b. Outdoor-air temperature.
 - c. Cooling (software) demand indication.
 - d. Time and time schedule.

- e. Condenser-water pump(s) on-off status (enabled or disabled).
- f. Condenser-water pump(s) on-off indication (operating or not operating).

C. Start and Stop Chilled-Water Pump(s):

- 1. Input:
 - a. Device: **[Flow][Pressure differential]** switch.
 - b. Location: Chilled-water piping.
 - c. Transference: **[Control voltage relay][DDC controller]**.
- 2. Output:
 - a. Device: **[Hard wired][Binary output]**.
 - b. Location: Motor controller.
 - c. Transference: Starter relay.
- 3. Action: Energize pump(s) when the condenser-water pump(s) and system start.
- 4. Display:
 - a. Chilled-water flow indication.
 - b. Chilled-water pump(s) on-off status (enabled or disabled).
 - c. Chilled-water pump(s) on-off indication (operating or not operating).

D. Start and Stop Cooling-Tower Fan(s):

- 1. Input:
 - a. Device: **[Flow][Pressure differential]** switch.
 - b. Location: Condenser-water piping.
 - c. Transference: **[Control relay][DDC controller]**.
- 2. Output:
 - a. Device: **[Hard wired][Binary output]**.
 - b. Location: Motor controller.
 - c. Transference: Starter relay.
- 3. Action: Energize fan(s) when the condenser-water pump(s) and system start.
- 4. Display:
 - a. Condenser-water flow indication.
 - b. Cooling-tower fan(s) on-off indication (operating or not operating).

E. Start and Stop Chillers:

- 1. Input:
 - a. Device: **[Flow][or][pressure differential]** switch.
 - b. Location: Chilled-**[and condenser-]**water piping.
 - c. Transference: **[Chiller controls][DDC controller]**.
- 2. Output:
 - a. Device: **[Hard wired][Binary output]**.

- b. Location: Chiller control panel.
 - c. Transference: Chiller controls.
- 3. Action: Energize chiller(s) internal control circuit when the condenser-water and chilled-water pump(s), and system start.
- 4. Display:
 - a. Condenser-water flow indication.
 - b. Chilled-water flow indication.
 - c. Chiller on-off indication (operating or not operating).
 - d. Chilled-water supply and return temperature.
 - e. Chilled-water temperature control-point adjustment.

F. Start and Stop Chiller(s):

- 1. Input:
 - a. Device: Flow switches.
 - b. Location: Condenser-water and chilled-water circuit.
 - c. Transference: [**Chiller terminal strip**][**DDC system**].
- 2. Output:
 - a. Device: [**Hard wired**][**Binary output**].
 - b. Location: Chiller control panel.
 - c. Transference: Chiller controls.
- 3. Action: Energize chiller internal control circuit when the condenser-water and chilled-water pump(s), and system start.
- 4. Display:
 - a. Condenser-water flow indication.
 - b. Chilled-water flow indication.
 - c. Chiller(s) on-off status (enabled or disabled).
 - d. Chiller(s) on-off indication (operating or not operating).
 - e. Chilled-water supply and return temperature.
 - f. Chilled-water temperature control-point adjustment.

G. Alternate Chiller(s):

- 1. Input:
 - a. Device: DDC controller.
 - b. Location: DDC software, <**Insert software definition**>.
 - c. Transference: DDC software.
- 2. Output Device:
 - a. Device: DDC controller command to chiller.
 - b. Location: Chiller control panel.
 - c. Transference: Chiller controls.
- 3. Action:

- a. Operate chiller(s) on lead-lag, **[alternating each startup][based on adjustable runtime hour set point]**.
 - b. Start additional chiller when load exceeds capacity of operating chillers as follows:
 - 1) When common chilled-water supply temperature exceeds set point for a **[30-minute]<Insert time>** period.
 - 2) When chiller power draw has reached its operator adjustable high limit for a **[30-minute]<Insert time>** period.
 - 3) When combination of outdoor temperature and time schedule ensure enough run-time before time schedule shutdown.
 - c. Stop chiller when load capacity of operating chillers drops to less than **[110]<Insert number>** percent of capacity of next chiller to be shut down for a **[30-minute]<Insert time>** period.
4. Action: **<Insert sequence and parameters>**.
 5. Display: Chiller(s) on-off indication (operating or not operating).
- H. Alarm Chiller(s) Start Failure:
1. Input:
 - a. Device: **[Software signal][Hardwired]<Insert devices>**.
 - b. Location: Chiller control panel.
 - c. Transference: DDC controller.
 2. Output:
 - a. Device: DDC controller.
 - b. Transference: Operator's workstation.
 3. Action: Signal alarm on signal from chiller control panel.
 4. Display:
 - a. Chiller "failure-to-start" indication.
 - b. **<Insert chiller controller alarm points>**.
- I. Start and Stop Chiller(s):
1. Input:
 - a. Device: Chiller control panel.
 - b. Location: Chiller.
 - c. Transference: DDC controller.
 2. Output:
 - a. Device: DDC controller.
 - b. Transference: Operator's workstation.
 3. Action: Report chiller electronic control, operating, and alarm functions.
 4. Display:
 - a. **<See chiller Sections for listing>**.

J. Chilled-Water Level:

1. Input:
 - a. Device: **[Level switch][Liquid level sensor]**.
 - b. Location: Expansion tank.
 - c. Transference: DDC controller.
2. Input:
 - a. Device: Liquid gage pressure switch.
 - b. Location: Makeup-water piping downstream from pressure-reducing valve.
 - c. Transference: DDC controller.
3. Output:
 - a. Device: DDC controller.
 - b. Transference: Operator's workstation.
4. Action: Signal alarm on **[expansion tank low level][low pressure]**.
5. Display: **[Expansion tank low-level][Low-pressure]** alarm.

K. Chilled-Water Supply Temperature:

1. Input:
 - a. Device: **[Liquid temperature sensor][or][liquid temperature sensor with liquid temperature transmitter]**.
 - b. Location: **[Common]**chilled-water supply piping.
 - c. Transference: DDC controller.
2. Output:
 - a. Device: DDC controller signal.
 - b. Location: Local panel.
 - c. Transference: Chiller control panel.
3. Action: Maintain chilled-water supply temperature.
 - a. Reset chilled-water supply temperature in response to greatest cooling demand to maintain at least one cooling control valve 90 percent open.
 - b. Reset chilled-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:
 - 1) **[44 deg F (7 deg C)]<Insert highest chilled-water temperature>** chilled water when outdoor-air temperature is **[80 deg F (26 deg C)]<Insert highest outdoor-air temperature>**.
 - 2) **[54 deg F (12 deg C)]<Insert lowest chilled-water temperature>** chilled water when outdoor-air temperature is **[60 deg F (15 deg C)]<Insert lowest operating outdoor-air temperature>**.
 - c. Reset chilled-water supply temperature based on constant return chilled-water temperature of **[54 deg F (12 deg C)]<Insert temperature>**.
 - d. **<Insert reset strategy>**.

4. Display:
 - a. Chilled-water supply temperature.
 - b. Chilled-water supply temperature set point.
- L. Condenser-Water Temperature:
 1. Input:
 - a. Device: **[Liquid temperature sensor][Liquid temperature sensor with liquid temperature transmitter]**.
 - b. Location: **[Cooling-tower sump][Common condenser-water supply piping]**.
 - c. Transference: DDC controller.
 2. Output:
 - a. Device: Analog output.
 - b. Location: DDC controller.
 - c. Transference: Control-valve actuator.
 3. Action: Modulate control valve open to cooling tower and closed to bypass to maintain when condenser-water supply temperature is above **[85 deg F (29 deg C)]<Insert value>** temperature set point. Modulate control valve closed to cooling tower and open to bypass when condenser-water supply temperature is below **[55 deg F (13 deg C)]<Insert value>** temperature set point.
 4. Output:
 - a. Device: DDC controller control relay.
 - b. Location: DDC controller.
 - c. Transference: Fan starter relay.
 5. Action:
 - a. Cycle tower fan(s) on and off to maintain **[55 deg F (13 deg C)]<Insert value>** temperature set point.
 - b. Cycle tower fan(s) on and off to maintain condenser-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:
 - 1) **[85 deg F (29 deg C)]<Insert highest condenser-water temperature>** condenser water when outdoor-air temperature is **[80 deg F (26 deg C)]<Insert highest outdoor-air temperature>**.
 - 2) **[55 deg F (13 deg C)]<Insert lowest condenser-water temperature>** condenser water when outdoor-air temperature is **[55 deg F (13 deg C)]<Insert lowest operating outdoor-air temperature>**.
 6. Output Assuming Fans Have Associated Variable-Frequency Motor-Control Circuitry:
 - a. Device: DDC controller digital output.
 - b. Location: DDC controller.
 - c. Transference: Fan variable-speed controller.
 7. Action Assuming Fans Have Associated Variable-Frequency Motor-Control Circuitry: Cycle tower fan(s) on and modulate fan speed from minimum to maximum to maintain **[55 deg F (13 deg C)]<Insert value>** temperature set point.
 8. Action: Cycle tower fan(s) on and off to maintain condenser-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

- a. [85 deg F (29 deg C)]<Insert highest condenser-water temperature> condenser water when outdoor-air temperature is [80 deg F (26 deg C)]<Insert highest outdoor-air temperature>.
- b. [55 deg F (13 deg C)]<Insert lowest condenser-water temperature> condenser water when outdoor-air temperature is [55 deg F (13 deg C)]<Insert lowest operating outdoor-air temperature>.

9. Display:

- a. Control-valve(s) position.
- b. Cooling-tower fan(s) on-off indication (operating or not operating).
- c. Cooling-tower fan(s) speed.
- d. Condenser-water supply temperature.
- e. Condenser-water supply temperature set point.
- f. Condenser-water return temperature.

M. Cooling-Tower Sump Heater:

1. Input:

- a. Device: **[Two-stage]**thermostat.
- b. Location: Cooling tower sump.
- c. Transference: Heater relay and control-valve actuator.

2. Output:

- a. Device: Heater relay and control-valve actuator.
- b. Location: Electric heater control panel and control-valve actuator in sump drain.
- c. Transference: Electric heater contactor and control-valve actuator.

3. Action:

- a. Energize sump heater if sump temperature falls below [40 deg F (4.5 deg C)]<Insert value> temperature set point.
- b. Open control valve in sump heater drain piping if sump temperature falls below [35 deg F (1.5 deg C)]<Insert value> temperature set point.

4. Display:

- a. Cooling-tower sump temperature.
- b. Cooling-tower sump heater on-off indication (operating or not operating).
- c. Cooling-tower control valve open-close indication.

N. Cooling-Tower Sump Heater:

1. Input:

- a. Device: **[Liquid temperature sensor][or][liquid temperature sensor with liquid temperature transmitter]**.
- b. Location: Cooling tower sump.
- c. Transference: DDC controller.

2. Output:

- a. Device: Binary output.
 - b. Location: Electric heater control panel [**and solenoid valve in sump drain**][**and control-valve actuator in sump drain**].
 - c. Transference: Electric heater contactor [**and solenoid valve**][**and control-valve actuator**].
 3. Action:
 - a. Energize sump heater if sump temperature falls below **<Insert value>** temperature set point.
 - b. Open control valve in sump heater drain piping if sump temperature falls below **<Insert value>** temperature set point.
 4. Display:
 - a. Cooling-tower sump temperature.
 - b. Cooling-tower sump heater on-off indication (operating or not operating).
 - c. Cooling-tower control valve open-close indication.
- O. Control Circulating Pump(s) Speed:
 1. Input Device:
 - a. Device: [**Liquid pressure differential transmitter**][**Liquid flow meter**][**Liquid flow sensor**].
 - b. Location: Chilled-water supply and return piping[**and condenser-water supply and return piping**] to chiller.
 - c. Transference: DDC controller.
 2. Output Device:
 - a. Device: DDC controller.
 - b. Location: Motor controller.
 - c. Transference: Pump variable-speed controller.
 3. Action:
 - a. Control pump speed to maintain flow through chiller.
 - b. Report pressure drop and flow.
- P. Circulation through Chiller:
 1. Input Device:
 - a. Device: [**Liquid pressure differential transmitter**][**Liquid flow meter**][**Liquid flow sensor**].
 - b. Location: Chilled-water supply and return piping[**and condenser-water supply and return piping**] to chiller.
 - c. Transference: DDC controller.
 2. Output Device:
 - a. Device: DDC controller.
 3. Action:

- a. Report pressure drop and flow through chiller.

Q. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system status, on-off.
3. Low-level cooling-tower sump alarm.
4. Outdoor temperature.
5. Cooling (software) demand indication.
6. Time and time schedule.
7. Condenser-water pump(s) on-off status (enabled or disabled).
8. Condenser-water pump(s) on-off indication (operating or not operating).
9. Condenser-water flow indication.
10. Chilled-water pump(s) on-off status (enabled or disabled).
11. Chilled-water pump(s) on-off indication (operating or not operating).
12. Cooling-tower fan(s) on-off indication (operating or not operating).
13. Chilled-water flow indication.
14. Refrigeration machine on-off indication (operating or not operating).
15. Chilled-water supply temperature.
16. Chilled-water return temperature.
17. Chilled-water temperature control-point adjustment.
18. Chiller(s) on-off status (enabled or disabled).
19. Chiller(s) on-off indication (operating or not operating).
20. Chiller "failure-to-start" indication.
21. Expansion tank low-level alarm.
22. Condenser-water sump (return) control-point temperature.
23. Condenser-water sump (return) temperature.
24. Condenser-water control-valve position.
25. Condenser-water supply temperature.
26. Cooling-tower sump temperature.
27. Cooling-tower sump heater on-off indication (operating or not operating).
28. Cooling-tower sump drain indication.
29. Chiller(s) power input (instantaneous).
30. Chilled-water pressure drop through chiller.
31. Chilled-water flow through chiller.
32. Condenser-water pressure drop through chiller.
33. Condenser-water flow through chiller.
34. Chiller condenser-water supply and return temperature.
35. Chiller chilled-water supply and return temperature.
36. System capacity in tons.
37. <Insert requirement>.

1.6 AIR-HANDLING-UNIT CONTROL SEQUENCES

A. Air-Handling Unit Time Schedule:

1. Occupied Time Schedule:

a. Input:

- 1) Device: DDC controller.
- 2) Location: Time schedule.
- 3) Transference: DDC controller.

- b. Output:
 - 1) Device: DDC controller.
- c. Action:
 - 1) Enable startup, initiation, and control.
 - 2) Energize unit on occupied/unoccupied cycle.
 - 3) Energize unit on day/night cycle.
 - 4) Energize unit on duty cycle.
 - 5) Energize return-air fans [**30 seconds**]**<Insert time>** after supply fans are energized.
 - 6) Do not enable mixed-air control during morning warm-up period.
 - a) Unoccupied: Position outdoor-air[**and relief-air**] dampers closed and return-air dampers open.
 - 7) Do not enable humidifier control during morning warm-up period.
 - 8) Enable control of heating coil(s) during morning warm-up period.
 - 9) Energize coil circulating pump(s).
 - 10) Return heating control valves to normal position when unit is cycled on.
 - 11) Do not enable cooling-coil control during morning warm-up period.

B. Start and Stop Supply Fan(s):

- 1. Enable:
 - a. Input:
 - 1) Device: Low limit temperature switch with [**manual**][**automatic**] reset.
 - 2) Location: Upstream of cooling coil.
 - 3) Transference: Starter relay.
 - b. Output:
 - 1) Device: Hard wired to motor controller[**and DDC controller**].
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Action:
 - 1) Allow start if temperature is above [**37 deg F (3 deg C)**]**<Insert temperature>**.
 - 2) Signal alarm if fan fails to start as commanded.
- 2. Enable:
 - a. Input:
 - 1) Device: Low limit temperature switch with [**manual**][**automatic**] reset.
 - 2) Location: [**Supply airstream**]**<Insert location>**.
 - 3) Transference: Starter relay.
 - b. Output:
 - 1) Device: Hard wired to motor controller[**and DDC controller**].
 - 2) Location: Motor controller.

- 3) Input Transference: Starter relay.
- c. Action:
 - 1) Allow start if temperature is below [120 deg F (49 deg C)]<Insert temperature>.
 - 2) Signal alarm if fan fails to start as commanded.
- 3. Enable:
 - a. Input:
 - 1) Device: Smoke detector with auxiliary contact [manual][automatic] reset.
 - 2) Location: Duct mounted [before][and][after][supply fan][air-handling unit].
 - 3) Location: Mounted in air-handling unit.
 - 4) Transference: Starter relay.
 - b. Output:
 - 1) Device: Hard wired.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Output Device: Hard wired through motor controller; DDC controller alarm.
 - d. Action:
 - 1) Allow start if airstream is free of products of combustion.
 - 2) Signal alarm if fan fails to start as commanded.
- C. Supply Fan(s) Variable-Volume Control:
 - 1. Fan Speed Control:
 - a. Input:
 - 1) Device: Air pressure transmitter.
 - 2) Location: Supply-duct static pressure referenced to ambient-space static pressure.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Transference: Variable-frequency motor controller.
 - c. Action:
 - 1) Maintain constant supply-duct static-pressure set point of <Insert value>.
 - 2) Set-Point Reset (for Systems with DDC of Individual Zone Terminals): Reset static-pressure set point based on the zone requiring the most pressure; reset set point lower until one zone damper is nearly wide open.
 - 3) Set variable-frequency drive to minimum speed when fan is stopped.
 - 2. Fan Airflow:
 - a. Input:

- 1) Device: Airflow **[sensor][transmitter]**.
 - 2) Location: Supply duct.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: DDC controller.
 - c. Action: Report supply-duct airflow.
 3. High Pressure:
 - a. Input:
 - 1) Device: Air pressure switch.
 - 2) Location: Supply duct referenced to outside the duct.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Binary output; DDC controller.
 - 2) Transference: Starter relay; operator's workstation.
 - c. Action: When static pressure rises above excessive-static-pressure set point of **<Insert value>**:
 - 1) Stop fan.
 - 2) Signal alarm.
- D. Return Fan(s) Variable-Volume Control:
1. Fan Speed Control:
 - a. Input:
 - 1) Device: Airflow **[sensor][transmitter]**.
 - 2) Location: Supply airstream and return airstream.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Variable-frequency drive.
 - 3) Transference: Variable-frequency drive controller.
 - c. Action:
 - 1) Maintain constant airflow offset between supply- and return-air fans.
 - 2) Set variable-frequency drive to minimum speed when fan is stopped.
 2. Fan Speed Control:
 - a. Input:
 - 1) Device: Air pressure **[sensor][differential transmitter]**.

- 2) Location: Indoor space static pressure referenced to outdoor static pressure.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Transference: Variable-frequency motor controller.
 - c. Action:
 - 1) Maintain constant indoor static-pressure set point of **[0.02-inch wg (5 Pa)]<Insert value>** positive for outdoors.
 - 2) Set variable-frequency drive to minimum speed when fan is stopped.
 - d. Action: Maintain constant indoor static pressure.
- E. Preheat Coil:
 - 1. Freeze Protection:
 - a. Input:
 - 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter][Thermostat]**.
 - 2) Location: After preheat coil.
 - 3) Transference: **[DDC controller][Starter relay]**.
 - b. Output:
 - 1) Device: **[Binary output][Hard wired]**.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Action: Allow start if duct temperature is above **[33 deg F (1 deg C)]<Insert temperature>**.
 - 2. Low-Temperature Operation:
 - a. Input:
 - 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]<Insert device>**.
 - 2) Location: Outdoor air.
 - 3) Transference: DDC controller.
 - b. Output Device:
 - 1) Device: Binary output.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Action:
 - 1) Energize coil circulating pump(s) at outdoor-air temperatures below **[35 deg F (2 deg C)]<Insert temperature>**.

3. [Supply][Discharge]-Air Temperature:
- a. Input:
 - 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
 - 2) Location: **[Supply][Discharge]** airstream.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Control valve.
 - 3) Transference: Control-valve actuator.
 - c. Action: Maintain air-temperature set point of **[55 deg F (13 deg C)]<Insert temperature>**.

F. Mixed-Air Control:

1. Minimum Position:
- a. Input:
 - 1) Device: DDC controller.
 - 2) Location: Time schedule.
 - 3) Transference: DDC controller.
 - b. Input:
 - 1) Device: Flow measuring station.
 - 2) Location: Outdoor-air intake.
 - 3) Transference: DDC controller.
 - c. Output:
 - 1) Device: Analog output.
 - 2) Location: Outdoor damper.
 - 3) Transference: Damper actuator(s).
 - d. Action:
 - 1) Open **[minimum outdoor-air dampers][outdoor-air dampers to minimum position]**.
 - 2) Modulate outdoor-air dampers to maintain minimum airflow at set point of **<Insert value>**.
2. Heating Reset:
- a. Input:
 - 1) Device: DDC controller.
 - 2) Location: Software.
 - 3) Transference: DDC controller.
 - b. Output:

- 1) Device: Analog output.
 - 2) Location: Outdoor dampers.
 - 3) Transference: Damper actuator(s).
 - c. Action: **[Close minimum outdoor-air dampers][Set outdoor-air dampers to minimum position]**.
3. Carbon Dioxide Reset:
 - a. Input:
 - 1) Device: Carbon dioxide transmitter.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Dampers.
 - 3) Transference: Damper actuator(s).
 - c. Action: Reset minimum outdoor-air damper position to maintain carbon dioxide set point of **<Insert value>**.
4. **[Supply][Mixed]-Air Temperature:**
 - a. Input:
 - 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
 - 2) Location: **[Supply-airstream][Mixed-air plenum]<Insert location>**.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Damper section.
 - 3) Transference: Damper actuator(s).
 - c. Action:
 - 1) Modulate outdoor-, return-, and relief-air dampers to maintain air-temperature set point of **[55 deg F (13 deg C)]<Insert temperature>**.
 - 2) Do not enable control during morning warm-up period.
5. Cooling Reset:
 - a. Input:
 - 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter][and moisture sensors and transmitters]**.
 - 2) Location: Outdoor- and return-air ducts.
 - 3) Input Transference: DDC controller.

b. Output:

- 1) Device: Analog output.
- 2) Location: Outdoor- and return-air ducts.
- 3) Transference: Damper actuator(s).

- c. Action: Set outdoor-air dampers to minimum position when outdoor-air **[temperature exceeds return-air temperature][enthalpy exceeds return-air enthalpy]**.

G. Humidifier:

1. Input:

- a. Device: Moisture sensor and transmitter.
- b. Location: **[Return airstream][Supply airstream][Space]<Insert location>**.
- c. Transference: DDC controller.

2. Output:

- a. Device: Analog output.
- b. Location: Humidifier.
- c. Transference: **[Valve actuator][and][pump]**.

3. Action:

- a. **[Modulate humidity control valve][Cycle humidifier pump][Cycle humidifier pump and modulate humidity control valve]**.
- b. Maintain humidity in straight-line relationship for the following conditions:
 - 1) 20 percent when outdoor-air temperature is **[minus 30 deg F (minus 35 deg C)]<Insert temperature>**.
 - 2) 40 percent when outdoor-air temperature is **[75 deg F (24 deg C)]<Insert temperature>**.

H. Evaporative Cooler:

1. Temperature:

a. Input:

- 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
- 2) Location: **[Supply][Discharge]** airstream.
- 3) Transference: DDC controller.

b. Output:

- 1) Device: Analog output.
- 2) Location: Evaporative cooler.
- 3) Transference: **[Valve actuator][and][pump]**.

c. Action:

- 1) **[Modulate evaporative cooler control valve][and][cycle evaporative cooler pump]**.

- 2) Maintain air-temperature set point of [55 deg F (13 deg C)]<Insert temperature>.

2. Humidity Limit:

a. Input:

- 1) Device: Moisture sensor and transmitter.
- 2) Location: [Return airstream][Supply airstream][Space]<Insert location>.
- 3) Transference: DDC controller.

b. Output:

- 1) Device: Analog output.
- 2) Location: Evaporative cooler.
- 3) Transference: [Valve actuator][and][pump].

c. Action:

- 1) Return [humidity control valve][humidifier pump][humidifier pump and humidity control valve] to their normal position.
- 2) Signal high humidity alarm.

I. Filters:

1. Differential Pressure:

a. Input:

- 1) Device: Pressure differential [switch][transmitter].
- 2) Location: Filter bank.
- 3) Transference: DDC controller.

b. Output:

- 1) Device: DDC controller.
- 2) Location: DDC controller.
- 3) Transference: Operator's workstation.

c. Action: Signal alarm on [low- and]high-pressure conditions.

J. [Hydronic][Steam] Heating Coil:

1. [Supply][Discharge]-Air Temperature:

a. Input:

- 1) Device: [Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter].
- 2) Location: [Supply][Discharge]-air [duct]<Insert location>.
- 3) Transference: DDC controller.

b. Output:

- 1) Device: Analog output.

- 2) Location: Heating-coil control valve.
 - 3) Input Transference: Normally [**open**][**closed**] valve actuator.
 - c. Action:
 - 1) Maintain supply-air-temperature set point of [**55 deg F (13 deg C)**]**<Insert temperature>** by modulating heating-coil control valve.
 - 2) Maintain supply-air-temperature set point in straight-line relationship for the following conditions:
 - a) [**65 deg F (18 deg C)**]**<Insert temperature>** when return-air temperature is [**70 deg F (21 deg C)**]**<Insert temperature>**.
 - b) [**55 deg F (13 deg C)**]**<Insert temperature>** when return-air temperature is [**75 deg F (24 deg C)**]**<Insert temperature>**.
 - 3) Maintain supply-air-temperature set point within limits in response to space temperature reset:
 - a) Minimum [**55 deg F (13 deg C)**]**<Insert temperature>**.
 - b) Maximum [**131 deg F (55 deg C)**]**<Insert temperature>**.
 - 4) During morning warm-up period, maintain supply-air-temperature set point of [**80 deg F (27 deg C)**]**<Insert temperature>**.
2. Space Temperature Reset:
 - a. Input:
 - 1) Device: Space [**air-temperature sensor**][**or**][**air-temperature sensor with air-temperature RTD transmitter**].
 - 2) Location: Indoor spaces served by system.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Heating-coil control valve.
 - 3) Input Transference: Normally [**open**][**closed**] valve actuator.
 - c. Action:
 - 1) Reset supply-air temperature in response to greatest heating demand.
 - 2) Supply-Air-Temperature Reset: Reset the supply-air temperature to outdoor temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.
3. Low-Temperature Operation:
 - a. Input Device:
 - 1) Device: [**Air-temperature sensor**][**or**][**air-temperature sensor with air-temperature RTD transmitter**]**<Insert device>**.
 - 2) Location: Outdoor air.
 - 3) Transference: DDC controller.

- b. Output Device:
 - 1) Device: Binary output.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
- c. Action:
 - 1) Energize coil circulating pump(s) at outdoor-air temperatures below [35 deg F (2 deg C)]<Insert temperature>.

K. Hydronic Cooling Coil:

1. [Supply][Discharge]-Air Temperature:

- a. Input:
 - 1) Device: [Air-temperature sensor][or][transmitter].
 - 2) Location: [Supply][Discharge]-air [duct]<Insert location>.
 - 3) Transference: DDC controller.
- b. Output:
 - 1) Device: Analog output.
 - 2) Location: Cooling-coil valve.
 - 3) Input Transference: Valve actuator.
- c. Action:
 - 1) Maintain supply-air-temperature set point of [55 deg F (13 deg C)]<Insert temperature> by modulating cooling-coil control valve.
 - 2) Maintain supply-air-temperature set point within limits in response to space temperature reset:
 - a) Minimum [55 deg F (13 deg C)]<Insert temperature>.
 - b) Maximum [68 deg F (20 deg C)]<Insert temperature>.
 - 3) Supply-Air-Temperature Reset: Reset the supply-air temperature to outdoor temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

2. Temperature Reset:

- a. Input:
 - 1) Device: [Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter].
 - 2) Location: Return-air [duct]<Insert location>.
 - 3) Transference: DDC controller.
- b. Output:
 - 1) Device: Analog output.
 - 2) Location: Cooling-coil control valve.

- 3) Transference: Valve actuator.
 - c. Action: Reset supply-air temperature in straight-line relationship for the following conditions:
 - 1) [65 deg F (18 deg C)]<Insert temperature> when return-air temperature is [70 deg F (21 deg C)]<Insert temperature>.
 - 2) [55 deg F (13 deg C)]<Insert temperature> when return-air temperature is [75 deg F (24 deg C)]<Insert temperature>.
 - d. Action:
 - 1) Reset supply-air temperature in response to greatest cooling demand.
 - 2) Supply-Air-Temperature Reset: Reset the supply-air temperature to outdoor temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.
3. Space Temperature Reset:
- a. Input:
 - 1) Device: Space [air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter].
 - 2) Location: Spaces served by system.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Cooling coil.
 - 3) Input Transference: Valve actuator.
 - c. Action:
 - 1) Reset supply-air temperature in response to greatest cooling demand.
 - 2) Supply-Air-Temperature Reset: Reset the supply-air temperature to outdoor temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.
4. Space Humidity Reset:
- a. Input:
 - 1) Device: Humidity sensor and transmitter.
 - 2) Location: Return-air [duct]<Insert location>.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Cooling-coil control valve.
 - 3) Transference: Valve actuator.
 - c. Action: Reset supply-air temperature to [55 deg F (13 deg C)]<Insert temperature> to maintain space relative humidity of [45]<Insert number> percent.

- L. Multizone Damper Control:
1. Spaces Temperature:
 - a. Input Device:
 - 1) Device: **[Air-temperature sensors][or][air-temperature sensor with air-temperature RTD transmitter]**.
 - 2) Location: Spaces served by system.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Multizone head.
 - 3) Transference: Damper actuators.
 - c. Action: Maintain the following space temperature set points:
 - 1) Occupied Cooling Temperature: **[75 deg F (24 deg C)]<Insert temperature>**.
 - 2) Occupied Heating Temperature: **[70 deg F (24 deg C)]<Insert temperature>**.
 - 3) Unoccupied Cooling Temperature: **[85 deg F (24 deg C)]<Insert temperature>**.
 - 4) Unoccupied Heating Temperature: **[65 deg F (18 deg C)]<Insert temperature>**.
- M. Coordination of Air-Handling Unit Sequences: Ensure that preheat, mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.
- N. Indicate the following on the operator's workstation display terminal:
1. DDC system graphic.
 2. DDC system on-off indication (operating or not operating).
 3. DDC system occupied/unoccupied mode.
 4. Outdoor-air-temperature indication.
 5. Supply-fan on-off indication (operating or not operating).
 6. Supply duct static-pressure indication.
 7. Supply duct static-pressure set point.
 8. Supply-fan airflow rate.
 9. Supply-fan speed.
 10. Return-fan on-off indication (operating or not operating).
 11. Space static-pressure indication.
 12. Space static-pressure set point.
 13. Return-fan airflow rate.
 14. Return-fan speed.
 15. Preheat-coil air-temperature indication.
 16. Preheat-coil air-temperature set point.
 17. Preheat-coil pump on-off indication (operating or not operating).
 18. Preheat-coil control-valve position.
 19. Mixed-air-temperature indication.
 20. Mixed-air-temperature set point.
 21. Mixed-air damper position.
 22. Relative humidity indication.
 23. Relative humidity set point.
 24. Relative humidity control-valve position.
 25. Filter air-pressure-drop indication.
 26. Filter low-air-pressure drop set point.

27. Filter high-air-pressure drop set point.
28. **[Supply][Discharge]**-air-temperature indication.
29. **[Supply][Discharge]**-air-temperature set point.
30. Heating-coil leaving-air-temperature indication.
31. Heating-coil leaving-air-temperature set point.
32. Heating-coil pump on-off indication (operating or not operating).
33. Heating-coil control-valve position.
34. Hot-deck air-temperature indication.
35. Hot-deck air-temperature set point.
36. Cooling-coil leaving-air-temperature indication.
37. Cooling-coil leaving-air-temperature set point.
38. Cooling-coil control-valve position.
39. Cold-deck air-temperature indication.
40. Cold-deck air-temperature set point.
41. Space temperature indication.
42. Space temperature set point.
43. Multizone damper position.

1.7 TERMINAL UNIT OPERATING SEQUENCE

A. Cabinet Unit Heater, **[Hydronic][Steam]**:

1. Space Temperature from Line-Voltage Thermostat:
 - a. Input:
 - 1) Device: Line-voltage thermostat.
 - 2) Location: Space.
 - b. Output:
 - 1) Device: Hard wired.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Action: Cycle fan to maintain **[75 deg F (24 deg C)]<Insert value>** space temperature.
2. Space Temperature from Air-Temperature Sensor:
 - a. Input:
 - 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
 - 2) Location: Occupied space.
 - 3) Transference: DDC controller.
 - b. Output Device:
 - 1) Device: Binary output.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Output Device:
 - 1) Device: Analog output.



- 2) Location: Control valve.
 - 3) Transference: Control-valve actuator.
 - d. Action: **[Cycle fan][Modulate valve]** to maintain **[75 deg F (24 deg C)]<Insert value>** space temperature.
3. Low-Temperature Safety:
 - a. Input Device: Line-voltage, on-off thermostat; mounted.
 - 1) Device: Line-voltage thermostat.
 - 2) Location: **[Return heating-water][Condensate]** pipe.
 - b. Output Device:
 - 1) Device: Hard wired.
 - 2) Location: Motor controller.
 - 3) Input Transference: Starter relay.
 - c. Action: Stop fan when **[return heating-water][condensate]** temperature falls below **[35 deg F (2 deg C)]<Insert temperature>**.

B. Cabinet Unit Heater, Electric:

1. Input:
 - a. Device: Line-voltage thermostat.
 - b. Location: Occupied space.
2. Output:
 - a. Device: Hard wired.
 - b. Location: Motor-controller and heater relay.
 - c. Transference: Starter relay.
3. Action: Cycle fan to maintain **[75 deg F (24 deg C)]<Insert value>** space temperature.

C. Unit Heater, **[Hydronic][Steam]**:

1. Space Temperature from Line-Voltage Thermostat:
 - a. Input:
 - 1) Device: Line-voltage thermostat.
 - 2) Location: Space.
 - b. Output:
 - 1) Device: Hard wired.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Action: Cycle fan to maintain **[75 deg F (24 deg C)]<Insert value>** space temperature.

2. Space Temperature from Air-Temperature Sensor:
 - a. Input:
 - 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
 - b. Output Device:
 - 1) Device: Binary output.
 - 2) Transference: Starter relay.
 - c. Output Device:
 - 1) Device: Analog output.
 - 2) Location: Control valve.
 - 3) Transference: Control-valve actuator.
 - d. Action: **[Cycle fan][Modulate valve]** to maintain **[75 deg F (24 deg C)]<Insert value>** space temperature.
3. Low-Temperature Safety:
 - a. Input Device: Line-voltage, on-off thermostat; pipe mounted.
 - 1) Device: Line-voltage thermostat.
 - 2) Location: **[Return heating-water][Condensate]** pipe.
 - b. Output Device:
 - 1) Device: Hard wired.
 - 2) Location: Motor controller.
 - 3) Input Transference: Starter relay.
 - c. Action: Stop fan when **[return heating-water][condensate]** temperature falls below **[35 deg F (2 deg C)]<Insert temperature>**.
- D. Unit Heater, Electric: Space thermostat cycles fan and sequences stages of heating.
 1. Space Temperature:
 - a. Input:
 - 1) Device: Electric multistage thermostat.
 - 2) Location: Space.
 - b. Output:
 - 1) Device: Hard wired.
 - 2) Location: Unit control panel.
 - 3) Transference: Electric multistage contactors.
 - c. Action: Sequence electric coil stages to maintain **[75 deg F (24 deg C)]<Insert value>**

space temperature.

E. Combustion-Air Unit Heaters:

1. Space Temperature from Line-Voltage Thermostat:

a. Input:

- 1) Device: Thermostat.
- 2) Location: Space.

b. Output:

- 1) Device: Low-voltage wiring.
- 2) Location: Control valve.
- 3) Transference: Valve actuator.

2. Space Temperature from Air-Temperature Sensor:

a. Input:

- 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
- 2) Location: Space.
- 3) Transference: DDC controller.

b. Output:

- 1) Device: Analog output.
- 2) Location: Control valve.
- 3) Transference: Valve actuator.

c. Action: Modulate valve to maintain **[75 deg F (24 deg C)]<Insert value>** space temperature.

F. Radiant Heating Cable, Electric:

1. Space Temperature:

a. Input:

- 1) Device: Electric thermostat.
- 2) Location: Space.

b. Output:

- 1) Device: Line-voltage wiring.
- 2) Location: Junction box.
- 3) Transference: Cable.

c. Action: Cycle power to maintain **[75 deg F (24 deg C)]<Insert value>** space temperature set point.

G. Radiant Heating Panel, Electric:

1. Space Temperature:
 - a. Input:
 - 1) Device: Electronic thermostat.
 - 2) Location: Space.
 - b. Output:
 - 1) Device: Low-voltage wiring.
 - 2) Location: Junction box.
 - 3) Transference: Line-voltage relay.
 - c. Action: Cycle power to maintain the following space temperature set points:
 - 1) Occupied: **[75 deg F (24 deg C)]<Insert temperature>**.
 - 2) Unoccupied: **[65 deg F (18 deg C)]<Insert temperature>**.

H. Radiant Heating Panel, Hydronic:

1. Space Temperature from Line-Voltage Thermostat:
 - a. Input:
 - 1) Device: Electronic thermostat.
 - 2) Location: Space.
 - b. Output:
 - 1) Device: Low-voltage wiring.
 - 2) Location: Control valve.
 - 3) Transference: Valve actuator.
 - c. Action: Cycle valve open and closed to maintain temperature set point.
2. Space Temperature from Air-Temperature Sensor:
 - a. Input:
 - 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: DDC analog output.
 - 2) Location: Control valve.
 - 3) Transference: Valve actuator.
 - c. Action: Modulate valve to maintain the following space temperature set points:
 - 1) Occupied: **[75 deg F (24 deg C)]<Insert temperature>**.
 - 2) Unoccupied: **[65 deg F (18 deg C)]<Insert temperature>**.

-
- I. Two-Pipe, Single-Coil, Fan-Coil Unit:
1. Manual Start:
 - a. Input:
 - 1) Device: Fan switch.
 - 2) Location: Integral to thermostat.
 - b. Output:
 - 1) Device: Hard wired.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Action: Start and stop fan.
 2. Space Temperature:
 - a. Input:
 - 1) Device: Electronic thermostat.
 - 2) Location: Space.
 - b. Output:
 - 1) Device: Low-voltage wiring.
 - 2) Location: Control valve.
 - 3) Transference: Valve.
 - c. Action: Modulate valve to maintain the following space temperature set points:
 - 1) Occupied Cooling Temperature: [75 deg F (24 deg C)]<Insert temperature>.
 - 2) Occupied Heating Temperature: [70 deg F (24 deg C)]<Insert temperature>.
 - 3) Unoccupied Cooling Temperature: [85 deg F (24 deg C)]<Insert temperature>.
 - 4) Unoccupied Heating Temperature: [65 deg F (18 deg C)]<Insert temperature>.
 3. Occupied Time Schedule:
 - a. Input:
 - 1) Device: DDC controller.
 - 2) Location: Time schedule.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Binary output.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Action: Start and stop fan.
 4. Space Temperature from Air-Temperature Sensor:

- a. Input:
 - 1) Device: Air-temperature sensor.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Control valve.
 - 3) Transference: Valve actuator.
 - c. Action: Modulate valve to maintain the following space temperature set points:
 - 1) Occupied: **[75 deg F (24 deg C)]<Insert temperature>**.
 - 2) Unoccupied: **[65 deg F (18 deg C)]<Insert temperature>**.
5. System Changeover:
- a. Input:
 - 1) Device: Liquid temperature sensor **[or][liquid temperature sensor with liquid transmitter]**.
 - 2) Location: Supply-water piping.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Binary output.
 - 2) Location: Control valve.
 - 3) Transference: Valve actuator.
 - c. Action: Reverse control-valve action to switch from heating to cooling.
- J. Four-Pipe, Hydronic Fan-Coil Unit:
- 1. Occupied Time Schedule:
 - a. Input:
 - 1) Device: DDC controller.
 - 2) Location: Time schedule.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Binary output.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay.
 - c. Action: Start and stop fan, and enable control.
 - 2. Space Temperature:
 - a. Input:



- 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
- b. Output:
- 1) Device: Analog output.
 - 2) Location: Control valve.
 - 3) Transference: Valve actuators.
- c. Action: Modulate control valves to maintain the following space temperature set points:
- 1) Occupied Cooling Temperature: **[75 deg F (24 deg C)]<Insert temperature>**.
 - 2) Occupied Heating Temperature: **[70 deg F (24 deg C)]<Insert temperature>**.
 - 3) Unoccupied Cooling Temperature: **[85 deg F (24 deg C)]<Insert temperature>**.
 - 4) Unoccupied Heating Temperature: **[65 deg F (18 deg C)]<Insert temperature>**.

K. Unit Ventilator:

1. Occupied Time Schedule:

- a. Input:
- 1) Device: DDC controller.
 - 2) Location: Time schedule.
 - 3) Transference: DDC controller.
- b. Output:
- 1) Device: Binary output.
 - 2) Location: Fan motor controller and damper.
 - 3) Transference: Starter relay and damper actuators.
- c. Action: Start and stop fan, move outdoor- and return-air dampers to **[minimum][maximum]** outdoor-air position, and enable control.

2. Space Temperature - Valves:

- a. Input:
- 1) Device: **[Air-temperature sensor][or][transmitter]**.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
- b. Output:
- 1) Device: Analog output.
 - 2) Location: Control valve.
 - 3) Transference: Valve actuator.
- c. Action: Modulate heating-water control valve and chilled-water control valve in sequence to maintain the following space temperature set points:

- 1) Occupied Cooling Temperature: [75 deg F (24 deg C)]<Insert temperature>.
 - 2) Occupied Heating Temperature: [70 deg F (24 deg C)]<Insert temperature>.
 - 3) Unoccupied Cooling Temperature: [85 deg F (24 deg C)]<Insert temperature>.
 - 4) Unoccupied Heating Temperature: [65 deg F (18 deg C)]<Insert temperature>.
3. Space Temperature - Dampers:
 - a. Input:
 - 1) Device: [**Air-temperature sensor**][or][air-temperature RTD transmitter].
 - 2) Location: Mixed-air plenum.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Dampers.
 - 3) Transference: Damper actuators.
 - c. Action: Modulate outdoor- and return-air dampers to maintain the following space temperature set points:
 - 1) Occupied Cooling Temperature: [75 deg F (24 deg C)]<Insert temperature>.
 - 2) Occupied Heating Temperature: [70 deg F (24 deg C)]<Insert temperature>.
 - 3) Unoccupied Cooling Temperature: [85 deg F (24 deg C)]<Insert temperature>.
 - 4) Unoccupied Heating Temperature: [65 deg F (18 deg C)]<Insert temperature>.
4. Supply-Air-Temperature Limit:
 - a. Input:
 - 1) Device: [**Air-temperature sensor**][or][air-temperature sensor with air-temperature RTD transmitter].
 - 2) Location: Discharge air.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Control valve and dampers.
 - 3) Transference: Valve and damper actuators.
 - c. Action: Override space temperature set point to control valves and dampers to prevent discharge air from dropping below a minimum set point of <Insert value>.
5. Warm-up Cycle:
 - a. Input:
 - 1) Device: DDC controller.
 - 2) Location: Time schedule.
 - 3) Input Transference: DDC controller.
 - b. Output:

- 1) Device: Analog output.
- 2) Location: Control valve and damper.
- 3) Transference: Valve and damper actuators.

- c. Action: Open heating-water control valve, close outdoor-air damper, and open return-air damper.

L. Heating Coils, **[Hydronic][Steam]**:

1. Space Temperature:

a. Input:

- 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
- 2) Location: Space.
- 3) Transference: DDC controller.

b. Output:

- 1) Device: Analog output.
- 2) Location: Control valve.
- 3) Transference: Valve actuator.

- c. Action: Modulate valve to maintain the following space temperature set points:

- 1) Occupied Cooling Temperature: **[75 deg F (24 deg C)]<Insert temperature>**.
- 2) Occupied Heating Temperature: **[70 deg F (24 deg C)]<Insert temperature>**.
- 3) Unoccupied Cooling Temperature: **[85 deg F (24 deg C)]<Insert temperature>**.
- 4) Unoccupied Heating Temperature: **[65 deg F (18 deg C)]<Insert temperature>**.

M. Heating Coils, Electric:

1. Space Temperature:

a. Input:

- 1) Device: Electric thermostat.
- 2) Location: Space.
- 3) Transference: Low-voltage control.

b. Output:

- 1) Device: Pilot relays.
- 2) Location: Heating-coil electrical cabinet.
- 3) Transference: Line-voltage relays.

- c. Action: Sequence stages of heating to maintain **[75 deg F (24 deg C)]<Insert value>** space temperature.

N. Radiators and Convectors, **[Hydronic][Steam]**:

1. Occupancy:

- a. Input:
 - 1) Device: Occupancy sensor.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: DDC controller.
 - c. Action: Report occupancy and enable occupied temperature set point.
2. Space Temperature:
- a. Input:
 - 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Control valve.
 - 3) Transference: Valve actuator.
 - c. Action: Modulate valve to maintain **[75 deg F (24 deg C)]<Insert value>** space temperature set point.
 - 1) Occupied Temperature: **[75 deg F (24 deg C)]<Insert temperature>**.
 - 2) Unoccupied Temperature: **[65 deg F (18 deg C)]<Insert temperature>**.
- O. Radiators and Convectors, Electric:
1. Space Temperature:
- a. Input:
 - 1) Device: Electric thermostat.
 - 2) Location: Space.
 - 3) Transference: Low-voltage control.
 - b. Output:
 - 1) Device: Pilot relays.
 - 2) Location: Radiator electrical cabinet.
 - 3) Transference: Line-voltage relays.
 - c. Action: Sequence stages of heating to maintain **[75 deg F (24 deg C)]<Insert value>** space temperature set point.
- P. Constant-Volume, Terminal Air Units, **[Hydronic][Steam]**:
1. Occupancy:

- a. Input:
 - 1) Device: Occupancy sensor.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: DDC controller.
 - c. Action: Report occupancy and enable occupied temperature set point.
2. Space Temperature:
- a. Input:
 - 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: Analog output.
 - 2) Location: Control valve.
 - 3) Transference: Valve actuator.
 - c. Action: Modulate valve to maintain the following space temperature set points:
 - 1) Occupied Cooling Temperature: **[75 deg F (24 deg C)]<Insert temperature>**.
 - 2) Occupied Heating Temperature: **[70 deg F (24 deg C)]<Insert temperature>**.
 - 3) Unoccupied Cooling Temperature: **[85 deg F (24 deg C)]<Insert temperature>**.
 - 4) Unoccupied Heating Temperature: **[65 deg F (18 deg C)]<Insert temperature>**.

Q. Variable-Air-Volume Terminal Air Units with **[Hydronic][Steam]** Coils:

1. Occupancy:
- a. Input:
 - 1) Device: Occupancy sensor.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
 - b. Device: DDC controller.
 - c. Action: Report occupancy and enable occupied temperature set point.
 - 1) Occupied Cooling Temperature: **[75 deg F (24 deg C)]<Insert temperature>**.
 - 2) Occupied Heating Temperature: **[70 deg F (24 deg C)]<Insert temperature>**.
 - 3) Unoccupied Cooling Temperature: **[85 deg F (24 deg C)]<Insert temperature>**.
 - 4) Unoccupied Heating Temperature: **[65 deg F (18 deg C)]<Insert temperature>**.
2. Space Temperature:

- a. Input:
 - 1) Device: **[Air-temperature sensor][or][transmitter]**.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
- b. Output:
 - 1) Device: Analog output.
 - 2) Location: Control damper and valve actuators.
 - 3) Input Transference: Control damper and valves.
- c. Action: Modulate damper and valve to maintain the following space temperature set points:
 - 1) Occupied Cooling Temperature: **[75 deg F (24 deg C)]<Insert temperature>**.
 - 2) Occupied Heating Temperature: **[70 deg F (24 deg C)]<Insert temperature>**.
 - 3) Unoccupied Cooling Temperature: **[85 deg F (24 deg C)]<Insert temperature>**.
 - 4) Unoccupied Heating Temperature: **[65 deg F (18 deg C)]<Insert temperature>**.
 - 5) Modulate damper actuator from full open to minimum position.
 - 6) When damper is at minimum position, modulate reheat coil valve from closed to open.
 - 7) If occupied space temperature is not maintained with valve open, modulate damper actuator from minimum position to **[100]<Insert number>** percent open.
 - 8) Reverse the sequence for full heating to full cooling.

R. Dual-Duct, Variable-Air-Volume Terminal Air Units:

- 1. Occupancy:
 - a. Input:
 - 1) Device: Occupancy sensor.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
 - b. Output:
 - 1) Device: DDC controller.
 - c. Action: Report occupancy and enable occupied temperature set point.
 - 1) Occupied Temperature: **[75 deg F (24 deg C)]<Insert temperature>**.
 - 2) Unoccupied Temperature: **[65 deg F (18 deg C)]<Insert temperature>**.
- 2. Space Temperature:
 - a. Input:
 - 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
 - 2) Location: Space.
 - 3) Transference: DDC controller.
 - b. Output:

- 1) Device: Analog output.
- 2) Location: Damper actuator(s).
- 3) Transference: Dampers.

c. Action: Modulate dampers to maintain the following space temperature set points:

- 1) Occupied Cooling Temperature: **[75 deg F (24 deg C)]<Insert temperature>**.
- 2) Occupied Heating Temperature: **[70 deg F (24 deg C)]<Insert temperature>**.
- 3) Unoccupied Cooling Temperature: **[85 deg F (24 deg C)]<Insert temperature>**.
- 4) Unoccupied Heating Temperature: **[65 deg F (18 deg C)]<Insert temperature>**.
- 5) When occupied space temperature is below set point, close cold-deck damper to minimum position and open hot-deck damper.
- 6) When occupied space temperature is above set point, close hot-deck damper to minimum position and open cold-deck damper.

S. Sequence Control:

1. Space Temperature:

a. Input:

- 1) Device: **[Air-temperature sensor][or][air-temperature sensor with air-temperature RTD transmitter]**.
- 2) Location: Space.
- 3) Transference: DDC controller.

b. Output:

- 1) Device: Analog output.
- 2) Location: Control damper and valve actuators.
- 3) Input Transference: Control dampers and valves.

c. Action: Modulate valves and dampers to maintain the following space temperature set points:

- 1) Occupied Cooling Temperature: **[75 deg F (24 deg C)]<Insert temperature>**.
- 2) Occupied Heating Temperature: **[70 deg F (24 deg C)]<Insert temperature>**.
- 3) Unoccupied Cooling Temperature: **[85 deg F (24 deg C)]<Insert temperature>**.
- 4) Unoccupied Heating Temperature: **[65 deg F (18 deg C)]<Insert temperature>**.
- 5) Modulate damper actuator from open to minimum position.
- 6) When damper is at minimum position, modulate finned-tube radiation valve from closed to fully open.
- 7) When finned-tube radiation valve is fully open, modulate reheat coil valve from closed to fully open.
- 8) If occupied space temperature is not maintained with both valves open, modulate damper actuator from minimum position to **[100]<Insert number>** percent open.
- 9) Reverse the sequence for full heating to full cooling.

T. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system on-off indication (operating or not operating).
3. DDC system occupied/unoccupied mode.
4. Outdoor-air-temperature indication.
5. Cabinet Unit Heater, Hydronic:

- a. Space temperature indication.
 - b. Space temperature set point.
 - c. Fan on.
- 6. Unit Heater, Hydronic:
 - a. Space temperature indication.
 - b. Space temperature set point.
 - c. Fan on.
- 7. Combustion-Air Unit Heaters:
 - a. Space temperature indication.
 - b. Space temperature set point.
 - c. Control-valve position.
- 8. Radiant Heating Panel, Hydronic:
 - a. Space temperature indication.
 - b. Space temperature set point.
 - c. Control-valve position.
- 9. Two-Pipe, Single-Coil, Fan-Coil Unit:
 - a. Space temperature indication.
 - b. Space temperature set point.
 - c. Control-valve position.
 - d. Supply-water temperature indication.
- 10. Four-Pipe, Hydronic Fan-Coil Unit:
 - a. Space temperature indication.
 - b. Space temperature set point.
 - c. Control-valve position.
- 11. Unit Ventilator:
 - a. DDC system on-off indication (operating or not operating).
 - b. Space temperature indication.
 - c. Space temperature set point.
 - d. Control-valve position.
 - e. Damper position.
- 12. Heating Coils, Hydronic:
 - a. Space temperature indication.
 - b. Space temperature set point.
 - c. Control-valve position.
- 13. Radiators and Convectors, Hydronic:
 - a. Space/area served.
 - b. Space temperature indication.
 - c. Space temperature set point.
 - d. Space temperature set point, occupied.
 - e. Space temperature set point, occupied standby.

- f. Space temperature set point, unoccupied.
- g. Control-valve position as percentage open.

14. Constant-Volume, Terminal Air Units, Hydronic:

- a. Space/area served.
- b. Space occupied/unoccupied.
- c. Space temperature indication.
- d. Space temperature set point, occupied.
- e. Space temperature set point, unoccupied.
- f. Control-valve position as percentage open.

15. Variable-Air-Volume Terminal Air Units with Hydronic Coils:

- a. Space/area served.
- b. Space occupied/unoccupied.
- c. Space temperature indication.
- d. Space temperature set point.
- e. Space cooling and heating temperature set point, occupied.
- f. Space cooling and heating temperature set point, unoccupied.
- g. Air-damper position as percentage open.
- h. Control-valve position as percentage open.

16. Dual-Duct, Variable-Air-Volume Terminal Air Units:

- a. Space/area served.
- b. Space occupied/unoccupied.
- c. Occupied space temperature indication.
- d. Occupied space temperature set point, occupied.
- e. Occupied space temperature set point, unoccupied.
- f. Hot-deck damper position as percentage open.
- g. Cold-deck damper position as percentage open.

17. Sequence Control:

- a. Space/area served.
- b. Space occupied/unoccupied.
- c. Space temperature indication.
- d. Space temperature set point, occupied.
- e. Space temperature set point, unoccupied.
- f. Damper position as percentage open.
- g. Control-valve positions as percentage open.

1.8 VENTILATION SEQUENCES

A. Combustion-Air, Makeup Unit Control, Electric:

1. Initiation:

- a. Input:
 - 1) Device: Auxiliary contact.
 - 2) Location: Served appliance.

- b. Output:
 - 1) Device: Hard wired.
 - 2) Location: Served appliance.
 - 3) Transference: Starter relay and electric solenoid.
 - c. Action: Start fan when appliance burner starts.
2. Space Temperature:
- a. Input:
 - 1) Device: Electronic multistage thermostat.
 - 2) Location: Space.
 - b. Output:
 - 1) Device: Hard wired.
 - 2) Location: Unit control panel.
 - 3) Transference: Electric multistage contactors.
 - c. Action: Sequence electric coil stages to maintain [75 deg F (24 deg C)]<Insert value> space temperature.
- B. Combustion-Air, Makeup Unit Control, [Hydronic][Steam]:
1. Initiation:
- a. Input:
 - 1) Device: Auxiliary contact.
 - 2) Location: Served appliance.
 - b. Output:
 - 1) Device: Hard wired.
 - 2) Location: Motor controller.
 - 3) Transference: Starter relay and electric solenoid.
 - c. Action: Start fan when appliance burner starts.
2. Space Temperature:
- a. Input:
 - 1) Device: Electronic thermostat.
 - 2) Location: Space.
 - b. Output:
 - 1) Device: Hard wired.
 - 2) Location: Control valve.
 - 3) Transference: Valve actuator.
 - c. Action: Modulate control valve to maintain [75 deg F (24 deg C)]<Insert value> space

temperature set point.

C. Gravity Roof Ventilator:

1. Input:
 - a. Device: **[Occupancy sensor][Electric thermostat]**.
 - b. Location: Space.
2. Output:
 - a. Device: Hard wired.
 - b. Location: Control damper.
 - c. Transference: Damper actuator.
3. Action: Open control damper when space **[is occupied][temperature rises above set point]**.

D. Exhaust Fan: **[Occupancy sensor][Light switch][Room thermostat]**.

1. Input:
 - a. Device: **[Occupancy sensor][Light switch][Electric thermostat]**.
 - b. Location: Space.
2. Output:
 - a. Device: Hard wired.
 - b. Location: Motor controller.
 - c. Transference: Starter relay.
3. Action: Cycle fan on when **[space is occupied][lights are turned on][space temperature rises above set point]**.

E. Kitchen Exhaust Fan: Occupancy sensor.

1. Input:
 - a. Device: Occupancy sensor.
 - b. Location: Space.
2. Output:
 - a. Device: Hard wired.
 - b. Location: Motor controller.
 - c. Transference: Starter relay.
3. Action: Start fan and energize makeup air unit when space is occupied.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 09 23 00C



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 23 00	23 09 00 00	Speed Instruments



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 09 23 11 - CONTROL VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ball-style control valves.
2. Butterfly-style control valves.
3. Globe-style control valves.
4. Pressure-independent control valves.
5. Solenoid valves.
6. Self-contained temperature-regulating valves.
7. Electric and electronic control valve actuators.
8. Pneumatic control valve actuators.

B. Related Requirements:

1. Section 230923 "Direct Digital Control (DDC) System for HVAC" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 DEFINITIONS

- A. Cv: Valve coefficient.
- B. DDC: Direct digital control.
- C. EPT: Ethylene-propylene terpolymer rubber.
- D. HNBR: Hydrogenated nitrile butadiene rubber.
- E. NBR: Nitrile butadiene rubber.
- F. PEEK: Polyether Ether Ketone rubber.
- G. PTFE: Polytetrafluoroethylene.
- H. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
- I. RTFE: Glass-fiber-reinforced PTFE.
- J. TFM: A chemically modified PTFE.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Ball-style control valves.
2. Butterfly-style control valves.
3. Globe-style control valves.
4. Pressure-independent control valves.
5. Solenoid valves.
6. Self-contained temperature-regulating valves.
7. Electric and electronic control valve actuators.
8. Pneumatic control valve actuators.

B. Product Data Submittals: For each product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions, including factors affecting performance.

C. Shop Drawings:

1. Include plans, elevations, sections, and[**mounting**] details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for pneumatic signal and main air tubing.

D. Delegated Design Submittals:

1. Schedule and design calculations for control valves and actuators, including the following:
 - a. Flow at project design and minimum flow conditions.
 - b. Pressure differential drop across valve at project design flow condition.
 - c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
 - d. Design and minimum control valve coefficient with corresponding valve position.
 - e. Maximum close-off pressure.
 - f. Leakage flow at maximum system pressure differential.
 - g. Torque required at worst-case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are indicated and coordinated with each other, using input from installers of the items involved:

1. Control valve installation location indicated in relationship to room, duct, pipe, and equipment.
2. Size and location of wall access panels for control valves installed behind walls.
3. Size and location of ceiling access panels for control valves installed above inaccessible ceilings.



1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control valves.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- C. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
- D. Code Compliance: Comply with governing energy code.
- E. Delegated Design: Engage a qualified professional[**engineer**], as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.
- F. Ground Fault: Properly ground products to prevent failing due to ground fault conditions.
- G. Backup Power Source: Serve control valve actuators from a backup power source where associated with systems and equipment served by a backup power source.
- H. Environmental Conditions: For actuators not available with integral enclosures complying with requirements indicated, house in protective secondary enclosures complying with requirements.
- I. Selection Criteria:
 - 1. Suitable for operation throughout full range of system operating conditions encountered.
 - a. Chilled Water: **<Insert pressure and coincident temperature requirements>**.
 - b. Condenser Water: **<Insert pressure and coincident temperature requirements>**.
 - c. Heat Recovery: **<Insert pressure and coincident temperature requirements>**.
 - d. Heating Hot Water: **<Insert pressure and coincident temperature requirements>**.
 - e. Steam: **<Insert pressure and coincident temperature requirements>**.
 - f. **<Insert system and requirements>**.
 - 2. Control Valve Leakage: FCI 70-2, **[Class IV]<Insert class>** or less leakage, unless otherwise indicated.
 - 3. Control Valve Pattern: **[Straight-through][Three-way][or][, six-way]**, as indicated on Drawings.
 - 4. Control Valve Flow Characteristics, Unless Otherwise Indicated:
 - a. Modulating, Two-Way Pattern: Equal percentage.
 - b. Modulating Three-Way Pattern: Linear flow. Total flow through the valve to be constant regardless of the valve's position.
 - c. Modulating Butterfly Valves: **[Linear flow][or][Equal percentage]**.
 - 5. Fail-Safe Positions, Unless Otherwise Indicated:

- a. Chilled Water: **[Close][Last position][Open]**.
 - b. Condenser Water: **[Close][Last position][Open]**.
 - c. Heat Recovery: **[Close][Last position][Open]**.
 - d. Heating Hot Water: **[Close][Last position][Open]**.
 - e. Steam: **[Close][Last position][Open]**.
 - f. **<Insert system and fail-safe position>**.
6. Stable Operation: Select control valves and actuators for stable operation throughout full range of operation, from design Cv at design flow to minimum Cv.
7. Control Valve Styles:
 - a. Hydronic Systems:
 - 1) Pipe Sizes NPS 2 (DN 50) and Smaller: **[Ball-][or][globe-]**style control valves.
 - 2) Pipe Sizes Larger than NPS 2 (DN 50): **[Ball-][butterfly-][or][globe-]**style control valves.
 - b. Steam Systems: Use **[ball-][or][globe-]**style control valves.
- J. Sizing Criteria: Unless otherwise indicated, select control valve size using the following:
 1. ISA Standards:
 - a. Control Valve Sizes and Flow Coefficients: ISA 75.01.01.
 - b. Control Valve Characteristics and Rangeability: ISA 75.11.01.
 2. Correction Factors: Consider viscosity, flashing, and cavitation corrections when selecting control valves.
 3. Ball-Style Control Valves: Select valve size with design Cv at design flow between **[65]<Insert number>** and **[75]<Insert number>** degrees of valve full open position and minimum Cv between **[15]<Insert number>** and **[25]<Insert number>** percent of open position.
 4. Butterfly-Style Control Valves: Select valve size with design Cv at design flow between **[65]<Insert number>** and **[75]<Insert number>** degrees of valve full open position and minimum Cv between **[15]<Insert number>** and **[25]<Insert number>** percent of open position.
 5. Globe-Style Control Valves: Select valve size to pass the design Cv at design flow with not more than **[95]<Insert number>** percent of stem travel.
 6. Modulating Control Valves in Hydronic Systems:
 - a. Select modulating control valve sizes at terminal equipment for a design Cv based on a pressure drop of **[5 psig (34 kPa)][7 psig (48 kPa)]<Insert value>** at design flow.
 - b. Calculate control valve minimum Cv at **[10]<Insert number>** percent of control valve design flow, with a coincident pressure differential equal to **[the system design pump head]<Insert requirement>**.
 - c. **<Insert requirement>**.
 7. Modulating Control Valves Steam Systems: Select modulating valve sizes for steam service with a pressure drop at design flow equal to lesser of the following:
 - a. **[50]<Insert number>** percent of the valve inlet pressure.
 - b. **[50]<Insert number>** percent of the absolute steam pressure at the valve inlet.
 8. Two-Position Valves: Select two-position control valves for full pipeline size.
- K. Pneumatic, Two-Position Control Valve Opening and Closing Characteristic:

1. Provide a smooth opening and closing characteristic slow enough to avoid an excessive rapid change in system pressure and potential water hammer.
 2. Provide an adjustable opening time (full closed to full open) and an adjustable closing time (full open to full closed) ranging from zero to **[10][15][30]<Insert value>** seconds. Make opening and closing times independently adjustable.
- L. Pneumatic Control Signal Distance Limitation: Not to exceed **[100 ft. (30 m)][200 ft. (60 m)]<Insert distance>** from controller. For longer distances, provide an electric/electronic control signal to the valve/actuator and an electric solenoid valve or electro-pneumatic transducer locally at the valve/actuator to convert the control signal to pneumatic.

2.2 BALL-STYLE CONTROL VALVES

A. Ball Valves with Threaded Ends, Two Way:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bonomi North America, Inc.]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Milwaukee Valve Company]**
 - f. **[NIBCO INC.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bonomi North America, Inc.]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Milwaukee Valve Company]**
 - f. **[NIBCO INC.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain threaded end two-way ball valves from single manufacturer.
4. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Controllable Flow Range: **[75]<Insert number>** percent open.
 - c. Flow Characteristic: Modified equal percentage.
 - d. Leakage: FCI 70-2, **[Class IV][Class VI]** or less.
 - e. Hydronic Pressure:
 - 1) Rating for Sizes NPS 1-1/4 (DN 32) and Smaller: Nominal **600 psig (4137 kPa)**.
 - 2) Rating for Sizes NPS 1-1/2 through NPS 2 (DN 38 through DN 50): Nominal **400 psig (2758 kPa)**.
 - 3) Close-off Pressure: **[200 psig (1379 kPa)]<Insert pressure>**.

- 4) Pressure Differential (Maximum): **[50 psig (345 kPa)]<Insert pressure>**.
- f. Hydronic Process Temperature Range: **[0 to 250 deg F (Minus 18 to plus 120 deg C)]<Insert temperature range>**.
- g. Saturated Steam Pressure: **[35 psig (215 kPa) for bronze body control valves][50 psig (345 kPa) for stainless steel body control valves]<Insert pressure>**.
5. Construction for Ball Valves with Threaded Ends, Two Way:
 - a. Size Range: **NPS 1/2 to NPS 2 (DN 13 to DN 50)**.
 - b. Body: Cast **[bronze][or][carbon steel][stainless steel]**.
 - c. End Connections: Female threaded (NPT) ends.
 - d. Ball: Stainless steel.
 - e. Ball Seats: Reinforced PTFE.
 - f. Stem and Stem Extension:
 - 1) Material to match ball.
 - 2) Blowout-proof design.
 - 3) For valves installed in insulated piping systems, provide stem extension **[extending beyond OD of insulation]**.
 - 4) Provide sleeve or other approved means to allow valve to be opened and closed without damaging the insulation and the insulation vapor barrier seal.
 - g. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
- B. Ball Valves with Flanged Ends, Two Way:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bonomi North America, Inc.]**
 - b. **[Milwaukee Valve Company]**
 - c. **[NIBCO INC.]**
 - d. **[Valve Solutions, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bonomi North America, Inc.]**
 - b. **[Milwaukee Valve Company]**
 - c. **[NIBCO INC.]**
 - d. **[Valve Solutions, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain flanged end two-way ball valves from single manufacturer.
 4. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.

- b. Controllable Flow Range: **[75]<Insert number>** percent open.
 - c. Flow Characteristic: Modified equal percentage.
 - d. Leakage: FCI 70-2, Class VI or less.
 - e. Hydronic Pressure:
 - 1) Rating: ASME B16.34, **[Class 150][Class 300][or][Class 150 or 300 required by application]**.
 - 2) Close-off Pressure: Equal to rating.
 - 3) Pressure Differential (Maximum): **<Insert pressure>**.
 - f. Hydronic Process Temperature Range: **[0 to 250 deg F (Minus 18 to plus 120 deg C)]<Insert temperature range>**.
 - g. Saturated Steam Pressure:
 - 1) Rating: Maximum **[50 psig (345 kPa)][150 psig (1034 kPa)]<Insert pressure>**
 - 2) Close-off Pressure: Equal to pressure rating.
 - 3) Differential (Maximum): **<Insert pressure>**.
 5. Standards for Ball Valves with Flanged Ends, Two Way: ASME B16.34, MSS SP-72.
 6. Features:
 - a. Full **[or standard]** port.
 - b. Replaceable ball, seat and stem packing.
 - c. Pressure equalized between body cavity and the line flow.
 - d. Mounting pad for actuator.
 7. Construction:
 - a. Size Range: **NPS 1/2 to NPS 12 (DN 13 to DN 300)**.
 - b. Body: Cast **[steel][or][stainless steel]**; two pieces.
 - c. End Connections: Flanged ends suitable for mating to ASME B16.5 flanges.
 - d. Ball: Stainless steel; vented.
 - e. Ball Seats: Reinforced PTFE.
 - f. Stem: Material to match ball; blowout-proof design.
 - g. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure.
- C. Ball Valves with Threaded Ends, Three Way:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bonomi North America, Inc.]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Milwaukee Valve Company]**
 - f. **[NIBCO INC.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bonomi North America, Inc.]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Milwaukee Valve Company]**
 - f. **[NIBCO INC.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain threaded end three-way ball valves from single manufacturer.
 4. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Controllable Flow Range: **[75]<Insert number>** percent open.
 - c. Flow Characteristic: Modified linear flow.
 - d. Leakage: FCI 70-2, **[Class III][Class IV][Class VI]** or less.
 - e. Hydronic Pressure:
 - 1) Rating for Sizes NPS 1-1/4 (DN 32) and Smaller: Nominal **600 psig (4137 kPa)**.
 - 2) Rating for Sizes NPS 1-1/2 through NPS 2 (DN 38 through DN 50): Nominal **400 psig (2758 kPa)**.
 - 3) Close-off Pressure: **[200 psig (1379 kPa)]<Insert pressure>**.
 - 4) Pressure Differential (Maximum): **[50 psig (345 kPa)]<Insert pressure>**.
 - f. Hydronic Process Temperature Range: **[0 to 250 deg F (Minus 18 to plus 120 deg C)]<Insert temperature range>**.
 5. Construction:
 - a. Size Range: **NPS 1/2 to NPS 2 (DN 13 to DN 50)**.
 - b. Body: Cast **[bronze][or][stainless steel]**.
 - c. End Connections: Female threaded (NPT) ends.
 - d. Ball: Stainless steel.
 - e. Ball Seats: Reinforced PTFE.
 - f. Stem and Stem Extension:
 - 1) Material to match ball.
 - 2) Blowout-proof design.
 - 3) For valves installed in insulated piping systems, provide stem extension **[extending beyond OD of insulation]**.
 - 4) Provide sleeve or other approved means to allow valve to be opened and closed without damaging the insulation and the insulation vapor barrier seal.
 - g. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
- D. Ball Valves with Characterized Disk and Threaded Ends, Two Way:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **<Insert manufacturer's name>**

3. Source Limitations: Obtain two-way ball valves, with characterized disk and threaded ends, from single manufacturer.
4. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Controllable Flow Range: **[75]<Insert number>** percent open.
 - c. Flow Characteristic: Equal percentage.
 - d. Leakage: FCI 70-2, **[Class IV][Class VI]** or less.
 - e. Hydronic Pressure:
 - 1) Rating for Sizes NPS 1-1/4 (DN 32) and Smaller: Nominal **600 psig (4137 kPa)**.
 - 2) Rating for Sizes NPS 1-1/2 through NPS 2 (DN 38 through DN 50): Nominal **400 psig (2758 kPa)**.
 - 3) Close-off Pressure: **[200 psig (1379 kPa)]<Insert pressure>**.
 - 4) Pressure Differential (Maximum): **[50 psig (345 kPa)]<Insert pressure>**.
 - f. Hydronic Process Temperature Range: **[0 to 250 deg F (Minus 18 to plus 120 deg C)]<Insert temperature range>**.
 - g. Rangeability: **[300]<Insert number>** to 1.

5. Construction:
 - a. Size Range: **NPS 1/2 to NPS 2 (DN 13 to DN 50)**.
 - b. Body: Cast bronze or forged brass **[with nickel plating]**.
 - c. End Connections: Female threaded (NPT) ends.
 - d. Ball: **[Chrome-plated brass or bronze][or][300 series stainless steel]**.
 - e. Ball Seats: Reinforced PTFE.
 - f. Characterizing Disk: **[Glass-filled PTFE,][Noryl,][polyphthalamide resin,]** Tefzel or stainless steel.
 - g. Stem and Stem Extension:
 - 1) Material to match ball.
 - 2) Blowout-proof design.
 - 3) For valves installed in insulated piping systems, provide stem extension **[extending beyond OD of insulation]**.
 - 4) Provide sleeve or other approved means to allow valve to be opened and closed without damaging the insulation and the insulation vapor barrier seal.

- h. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.

E. Ball Valves with Characterized Disk and Flanged Ends, Two Way:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain two-way ball valves, with characterized disk and flanged ends, from single manufacturer.
4. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Controllable Flow Range: **[75]<Insert number>** percent open.
 - c. Flow Characteristic: Equal percentage.
 - d. Leakage: FCI 70-2, **[Class III][Class IV][Class VI]** or less.
 - e. Hydronic Pressure:
 - 1) Rating: In accordance with ASME B16.1, Class B.
 - 2) Close-off Pressure:
 - a) Class 125: **175 psig (1207 kPa).**
 - b) Class 250: **310 psig (2137 kPa).**
 - 3) Pressure Differential (Maximum): **[50 psig (345 kPa)]<Insert pressure>.**
 - f. Hydronic Process Temperature Range: **[0 to 250 deg F (Minus 18 to plus 120 deg C)]<Insert temperature range>.**
 - g. Rangeability: **[300]<Insert number>** to 1.
5. Construction:
 - a. Size Range: **NPS 2-1/2 to NPS 6 (DN 65 to DN 150).**
 - b. Body: Cast iron, Class B in accordance with ASME B16.1.
 - c. End Connections: Flanged, Class 125 or 250 in accordance with ASME B16.1.

- d. Ball: Stainless steel.
- e. Ball Seats: Reinforced PTFE.
- f. Characterizing Disk: Stainless steel.
- g. Stem and Stem Extension: Material to match ball; blowout-proof design.
- h. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.

F. Ball Valves with Characterized Disk and Threaded Ends, Three Way:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - c. **[Johnson Controls, Inc.]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - c. **[Johnson Controls, Inc.]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain three-way ball valves, with characterized disk and threaded ends, from single manufacturer.
4. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Controllable Flow Range: **[75]<Insert number>** percent open.
 - c. Flow Characteristics:
 - 1) A-Port: Equal percentage.
 - 2) B-Port: Modified for constant common port flow.
 - d. Leakage: FCI 70-2, **[Class IV][Class VI]** or less for A-port; **[one][two]** percent for B-port.
 - e. Hydronic Pressure:
 - 1) Rating for Sizes NPS 1 (DN 25) and Smaller: Nominal **600 psig (4137 kPa)**.
 - 2) Rating for Sizes NPS 1-1/4 through NPS 2 (DN 32 through DN 50): Nominal **400 psig (2758 kPa)**.
 - 3) Close-off Pressure: **[200 psig (1379 kPa)]<Insert pressure>**.
 - 4) Pressure Differential (Maximum): **[50 psig (345 kPa)]<Insert pressure>**.
 - f. Hydronic Process Temperature Range: **[0 to 250 deg F (Minus 18 to plus 120 deg C)]<Insert temperature range>**.
 - g. Rangeability: **[300]<Insert number>** to 1.

5. Construction:

- a. Size Range: **NPS 1/2 to NPS 2 (DN 13 to DN 50).**
- b. Body: Cast bronze or forged brass[**with nickel plating**].
- c. End Connections: Female threaded (NPT) ends.
- d. Ball: [**Chrome-plated brass or bronze**][or][**300 series stainless steel**].
- e. Ball Seats: Reinforced PTFE.
- f. Characterizing Disk: [**Glass-filled PTFE,**][**Noryl,**][**polyphthalamide resin,**] Tefzel or stainless steel.
- g. Stem and Stem Extension:
 - 1) Material to match ball.
 - 2) Blowout-proof design.
 - 3) For valves installed in insulated piping systems, provide stem extension[**extending beyond OD of insulation**].
 - 4) Provide sleeve or other approved means to allow valve to be opened and closed without damaging the insulation and the insulation vapor barrier seal.
- h. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.

G. Ball Valves with Characterized Disk, Six Way:

1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. [**Belimo Aircontrols (USA), Inc**]
 - b. [**Honeywell Building Solutions; Honeywell International, Inc.**]
 - c. [**IMI Hydronic Engineering Inc**]
 - d. [**Johnson Controls, Inc.**]
 - e. [**Siemens Industry, Inc., Building Technologies Division**]
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [**Belimo Aircontrols (USA), Inc**]
 - b. [**Honeywell Building Solutions; Honeywell International, Inc.**]
 - c. [**IMI Hydronic Engineering Inc**]
 - d. [**Johnson Controls, Inc.**]
 - e. [**Siemens Industry, Inc., Building Technologies Division**]
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain six-way ball valves, with characterized disk, from single manufacturer.
4. Description: Functionality of four two-way control valves. One control valve and electronic actuator performs changeover and modulating control for a single coil in a four-pipe system with full close-off for both heating and cooling.
5. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.

- b. Flow Characteristics: Equal percentage or linear.
 - c. Leakage: Zero.
 - d. Hydronic Pressure:
 - 1) Rating: **230 psig (1585 kPa)**.
 - 2) Close-off Pressure: **[50 psig (345 kPa)]<Insert pressure>**.
 - 3) Pressure Differential (Maximum): **[15 psig (103 kPa)]<Insert pressure>**.
 - e. Hydronic Process Temperature Range: **[43 to 180 deg F (6 to 82 deg C)]<Insert temperature range>**.
6. Construction:
- a. Size Range: **NPS 1/2 to NPS 1 (DN 13 to DN 25)**.
 - b. Body: Forged brass[**with nickel plating**].
 - c. End Connections: Female threaded (NPT) ends.
 - d. Ball: Chrome-plated brass or bronze, stainless steel.
 - e. Ball Seats: Reinforced PTFE.
 - f. Characterizing Disk: Chrome-plated steel, brass, or stainless steel.
 - g. Stem and Stem Extension: Material to match ball; blowout-proof design.
 - h. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
- H. Ball Valves with Segmented Ball, Two Way:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bray Commercial]**
 - b. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - c. **[Flo-Tite, Inc.]**
 - d. **[Flowserve Corporation]**
 - e. **[Max-Air Technology Inc.]**
 - f. **[Valve Solutions, Inc.]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bray Commercial]**
 - b. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - c. **[Flo-Tite, Inc.]**
 - d. **[Flowserve Corporation]**
 - e. **[Max-Air Technology Inc.]**
 - f. **[Valve Solutions, Inc.]**
 - g. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain two-way ball valves, with segmented ball, from single manufacturer.
 - 4. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.

- b. Controllable Flow Range: **[75][Insert number]** percent open.
 - c. Flow Characteristic: Equal percentage or modified equal percentage.
 - d. Leakage: FCI 70-2, Class VI.
 - e. Hydronic Pressure:
 - 1) Rating: ASME B16.34, **[Class 150][Class 300][or][Class 150 or 300 as required by application]**.
 - 2) Close-off Pressure: **[250 psig (1724 kPa)]<Insert pressure>**.
 - 3) Pressure Differential (Maximum): **[Approximately 1/3 inlet pressure]<Insert pressure>**.
 - f. Hydronic Process Temperature Rating: **[0 to 250 deg F (Minus 18 to plus 120 deg C)][Minus 20 to plus 450 deg F (Minus 29 to plus 232 deg C)]<Insert temperature range>**.
 - g. Saturated Steam Pressure:
 - 1) Rating: Maximum **[50 psig (345 kPa)][125 psig (862 kPa)]<Insert pressure>**
 - 2) Close-off Pressure: **[50 psig (345 kPa)][125 psig (862 kPa)]<Insert pressure>**.
 - 3) Differential (Maximum): **<Insert pressure>**.
 - h. Rangeability: **[300]<Insert number>** to 1.
5. Standards: ASME B16.10, ASME B16.34.
6. Features:
- a. Stem and ball pinned and welded.
 - b. Replaceable ball, seat and packing.
7. Construction:
- a. Size Range: **[NPS 1 to NPS 12 (DN 25 to DN 300)][NPS 1 to NPS 16 (DN 25 to DN 400)][NPS 1 to NPS 24 (DN 25 to DN 600)]<Insert size range>**.
 - b. End Connections: Flanged ends suitable for mating to ASME B16.5 flanges. Female threaded (NPT) ends are also acceptable for valve sizes **NPS 2 (DN 50)** and smaller.
 - c. Face-to-Face Dimensions: ASME B16.10 or ISA S75.08.02.
 - d. Body: Cast **[carbon][or][stainless]** steel.
 - e. Ball: Stainless steel.
 - f. Seat: TFM or reinforced PTFE.
 - g. Stem: Stainless steel.
 - h. Stem Packing: PTFE V-rings.
 - i. Label each valve with following:
 - 1) Manufacturer's name, model number, and serial number.
 - 2) Body size.
 - 3) Flow directional arrow.

I. Ball Valves with Segmented Ball, Three Way:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Valve Solutions, Inc.]**
 - b. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Valve Solutions, Inc.]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain three-way ball valves, with segmented ball, from single manufacturer.
4. Arrangement: Two single-port valves mated to a fabricated tee with interconnecting mechanical linkage **[or a single three-way valve with two ports]**.
5. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Controllable Flow Range: **[75]<Insert number>** percent open.
 - c. Flow Characteristic: Equal percentage.
 - d. Leakage: FCI 70-2, Class VI.
 - e. Hydronic Pressure:
 - 1) Rating: ASME B16.34, **[Class 150][Class 300][or][Class 150 or 300 as required by application]**.
 - 2) Close-off Pressure: **250 psig (1724 kPa)**.
 - 3) Pressure Differential (Maximum): **[Approximately one-third inlet pressure]<Insert pressure>**.
 - f. Hydronic Process Temperature Rating: **[0 to 250 deg F (Minus 18 to plus 120 deg C)]<Insert temperature range>**.
 - g. Rangeability: **[300]<Insert number>** to 1.
6. Standards: ASME B16.10, ASME B16.34.
7. Features:
 - a. Stem and ball pinned and welded.
 - b. Replaceable ball, seat and shaft packing.
8. Construction:
 - a. Size Range: **[NPS 3 to NPS 12 (DN 80 to DN 300)]<Insert size>**
 - b. End Connections: Flanged ends suitable for mating to ASME B16.5 flanges.
 - c. Face-to-Face Dimensions: ASME B16.10 or ISA S75.08.02.
 - d. Body: Cast **[carbon][or][stainless]** steel.
 - e. Ball: Stainless steel.
 - f. Seat: TFM or graphite reinforced PTFE.
 - g. Stem: Stainless steel.
 - h. Stem Packing: PTFE V-rings and graphite packing follower.
 - i. Label each valve with following:
 - 1) Manufacturer's name, model number, and serial number.
 - 2) Body size.
 - 3) Flow directional arrow.

J. Ball Valves with Full Ball and Characterized V-Notch, Two Way:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Bray Commercial]**
 - b. **[Flo-Tite, Inc.]**
 - c. **[Flow-Tek; a subsidiary of Bray International]**
 - d. **[Valve Solutions, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bray Commercial]**
 - b. **[Flo-Tite, Inc.]**
 - c. **[Flow-Tek; a subsidiary of Bray International]**
 - d. **[Valve Solutions, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain two-way ball valves, with full ball and characterized v-notch, from single manufacturer.
4. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Controllable Flow Range: **[80][Insert number]** percent open.
 - c. Flow Characteristic: Equal percentage[**or modified equal percentage**].
 - d. Leakage: FCI 70-2, Class VI.
 - e. Hydronic Pressure:
 - 1) Rating:
 - a) Sizes NPS 2 (DN 50) and Smaller: ASME B16.34, Class 300 or 600.
 - b) Larger Sizes: ASME B16.34, **[Class 150][Class 300][or][Class 150 or 300 as required by application]**.
 - 2) Close-off Pressure: Equal to rating.
 - 3) Pressure Differential (Maximum): **[Approximately 1/3 inlet pressure]<Insert pressure>**.
 - f. Hydronic Process Temperature Rating: **[0 to 250 deg F (Minus 18 to plus 120 deg C)][Minus 20 to plus 450 deg F (Minus 29 to plus 232 deg C)]<Insert temperature range>**.
 - g. Saturated Steam Pressure:
 - 1) Rating: Maximum **[50 psig (345 kPa)][150 psig (1034 kPa)]<Insert pressure>**
 - 2) Close-off Pressure: Equal to pressure rating at maximum temperature.
 - 3) Differential (Maximum): **<Insert pressure>**.
 - h. Rangeability: Varies from 200 to 1 up to **[800]<Insert number>** to 1 based on notch pattern of ball.
5. Standards: ASME B16.34, MSS SP-72.
6. Features:
 - a. Full[**or standard**] port.
 - b. Replaceable ball, seat, shaft bushings, and packing.
 - c. Pressure equalized between body cavity and the line flow.
 - d. Universal mounting pad complying with ISO 5211 for actuator mounting.

7. Construction:
 - a. Size Range: **NPS 1/2 to NPS 12 (DN 15 to DN 300).**
 - b. Sizes NPS 2 (DN 50) and Smaller:
 - 1) End Connections: Female threaded (NPT) ends complying with ASME B1.20.1 or flanged ends suitable for mating to ASME B16.5 flanges.
 - 2) Stem Seals: Live-loaded, self-adjusting, primary and secondary sealing using belleville washers.
 - a) Primary Seal: Combination of thrust washer and thrust washer protector.
 - b) Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.
 - c. Sizes Larger than NPS 2 (DN 50):
 - 1) Stem Seals: Independent packing gland, adjusted without removing mounting hardware or operator, and contoured to uniformly distribute load across packing.
 - a) Primary Seal: Combination of thrust washer and thrust washer protector.
 - b) Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.
 - 2) Flanged ends suitable for mating to ASME B16.5 flanges.
 - d. Face-to-Face Dimension: ASME B16.10 short or long pattern, or ISA S75.08.02.
 - e. Body: **[Carbon][or][stainless]** steel; two- or three-piece design.
 - f. Ball: Stainless steel.
 - g. Seat: Reinforced PTFE, TFM, PEEK.
 - h. Shaft: Stainless steel.
8. Label each valve with following:
 - a. Manufacturer's name, model number, and serial number.
 - b. Body size.
 - c. Flow directional arrow.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. Butterfly Valves with Resilient Seats, Two Way:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bonomi North America, Inc.]**
 - c. **[Bray Commercial]**
 - d. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Keystone; Emerson Electric Co., Automation Solutions]**
 - g. **[Max-Air Technology Inc.]**
 - h. **[Max-Seal, Inc.]**
 - i. **[Milwaukee Valve Company]**
 - j. **[NIBCO INC.]**
 - k. **[Siemens Industry, Inc., Building Technologies Division]**

- l. [Valve Solutions, Inc.]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Belimo Aircontrols (USA), Inc]
 - b. [Bonomi North America, Inc.]
 - c. [Bray Commercial]
 - d. [Honeywell Building Solutions; Honeywell International, Inc.]
 - e. [Johnson Controls, Inc.]
 - f. [Keystone; Emerson Electric Co., Automation Solutions]
 - g. [Max-Air Technology Inc.]
 - h. [Max-Seal, Inc.]
 - i. [Milwaukee Valve Company]
 - j. [NIBCO INC.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. [Valve Solutions, Inc.]
 - m. <Insert manufacturer's name>
 3. Source Limitations: Obtain two-way butterfly valves, with resilient seats, from single manufacturer.
 4. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Flow Characteristic: Linear or modified equal percentage.
 - c. Leakage: Bubble tight.
 - d. Hydronic Pressure:
 - 1) Rating: Minimum [150 psig (1034 kPa)][175 psig (1207 kPa)][200 psig (1379 kPa)][250 psig (1724 kPa)]<Insert pressure>.
 - 2) Shutoff Pressure: Minimum [150 psig (1034 kPa)][175 psig (1207 kPa)][200 psig (1379 kPa)][250 psig (1724 kPa)]<Insert pressure>.
 - 3) Differential (Maximum): <Insert pressure>.
 - e. Hydronic Process Temperature Range: [0 to 225 deg F (Minus 18 to plus 107 deg C)]<Insert temperature range>.
 5. Standards: MSS SP-67.
 6. Features:
 - a. Bidirectional, dead end service[**with downstream flange removed**].
 - b. Extended neck of body to accommodate up to **2-inch- (50-mm-)** thick insulation.
 - c. Replaceable disc, shaft bearings/bushings[**and seat**].
 7. Construction:
 - a. Size Range: [NPS 2 to NPS 12 (DN 65 to DN 300)][NPS 2 to NPS 24 (DN 65 to DN 600)]<Insert size range>
 - b. Body: Cast iron or ductile iron; single flange, fully lugged and suitable for mating to ASME B16.5 flanges.
 - c. Disc: [Aluminum bronze][nylon-coated ductile iron][or][stainless steel]<Insert material>.
 - d. Seat: Reinforced [EPDM]<Insert material>.

- e. Stem(s): Stainless steel.
 - f. Stem Bushings: Reinforced PTFE.
 - g. Corrosion-resistant nameplate indicating the following:
 - 1) Manufacturer's name, model number, and serial number.
 - 2) Body size.
 - 3) Body and trim materials.
 - 4) Flow arrow.
- B. Butterfly Valves with Resilient Seats, Three Way:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **[Valve Solutions, Inc.]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **[Valve Solutions, Inc.]**
 - g. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain three-way butterfly valves, with resilient seats, from single manufacturer.
 4. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
 5. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Flow Characteristic: Linear or modified equal percentage.
 - c. Leakage: Bubble tight.
 - d. Hydronic Pressure:
 - 1) Rating: Minimum **[150 psig (1034 kPa)][175 psig (1207 kPa)][200 psig (1379 kPa)]<Insert pressure>**.
 - 2) Close-off Pressure: Minimum **[150 psig (1034 kPa)][175 psig (1207 kPa)][200 psig (1379 kPa)]<Insert pressure>**.
 - 3) Differential (Maximum): **<Insert pressure>**.
 - e. Hydronic Process Temperature Range: **[0 to 225 deg F (Minus 18 to plus 107 deg C)]<Insert temperature range>**.
 6. Standards: MSS SP-67.

7. Features:
 - a. Bidirectional service.
 - b. Extended neck of body to accommodate up to **2-inch- (50-mm-)** thick insulation.
 - c. Replaceable disc, shaft bearings/bushings[**and seat**].
8. Construction:
 - a. Size Range: **[NPS 2 to NPS 12 (DN 65 to DN 300)][NPS 2 to NPS 24 (DN 65 to DN 600)]<Insert size range>**
 - b. Body: Cast iron or ductile iron; single flange, fully lugged and suitable for mating to ASME B16.5 flanges.
 - c. Disc: **[Aluminum bronze][Nylon-coated ductile iron][or][stainless steel]<Insert material>**.
 - d. Stem(s): Stainless steel.
 - e. Seat: Reinforced **[EPDM][or]<Insert material>**.
 - f. Stem Bearings/Bushings: Reinforced PTFE.
 - g. Corrosion-resistant nameplate indicating the following:
 - 1) Manufacturer's name, model number, and serial number.
 - 2) Body size.
 - 3) Body and trim materials.
 - 4) Flow arrow.

C. High-Performance Butterfly Valves, Two Way:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - d. **[Flowserve Corporation]**
 - e. **[Keystone; Emerson Electric Co., Automation Solutions]**
 - f. **[Max-Seal, Inc.]**
 - g. **[Milwaukee Valve Company]**
 - h. **[NIBCO INC.]**
 - i. **[Valve Solutions, Inc.]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - d. **[Flowserve Corporation]**
 - e. **[Keystone; Emerson Electric Co., Automation Solutions]**
 - f. **[Max-Seal, Inc.]**
 - g. **[Milwaukee Valve Company]**
 - h. **[NIBCO INC.]**
 - i. **[Valve Solutions, Inc.]**

- j. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain two-way high-performance butterfly valves from single manufacturer.
- 4. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Flow Characteristic: Linear or modified equal percentage.
 - c. Leakage: FCI 70-2, Class VI.
 - d. Hydronic Pressure:
 - 1) Rating: ASME B16.34, [**Class 150**][**Class 300**][or][**Class 150 or 300 as required by application**].
 - 2) Close-off Pressure: Equal to rating.
 - 3) Pressure Differential (Maximum): **<Insert pressure>**.
 - e. Hydronic Process Temperature Rating: [**0 to 250 deg F (Minus 18 to plus 120 deg C)**][**Minus 20 to plus 450 deg F (Minus 29 to plus 232 deg C)**]**<Insert temperature range>**.
 - f. Saturated Steam Pressure
 - 1) Rating: Maximum [**50 psig (345 kPa)**][**150 psig (1034 kPa)**]**<Insert pressure>**
 - 2) Close-off Pressure: Equal to pressure rating.
 - 3) Differential (Maximum): **<Insert pressure>**.
 - g. Rangeability: [**100**]**<Insert number>** to 1.
- 5. Standards: ASME B16.34, MSS SP-68.
- 6. Features:
 - a. Bidirectional, end-of-line service[**with downstream flange removed**].
 - b. Extended neck of body to accommodate up to **2-inch- (50-mm-)** thick insulation.
 - c. Replaceable seat, disc and shaft bearings/bushings.
- 7. Construction:
 - a. Size Range: [**NPS 2-1/2 to NPS 36 (DN 65 to DN 900)**]**<Insert size range>**
 - b. Body: Cast [**steel**][or][**stainless steel**]; single flange, fully lugged and suitable for mating to ASME B16.5 or ASME B16.47 flanges.
 - c. Disc: Stainless steel.
 - d. Seat: Reinforced PTFE [**or**]**<Insert material>** with stainless steel retaining ring.
 - e. Stem(s): Stainless steel.
 - f. Stem Bearings: Stainless steel.
 - g. Stem Packing: PTFE.
 - h. Corrosion-resistant nameplate indicating the following:
 - 1) Manufacturer's name, model number, and serial number.
 - 2) Body size.
 - 3) Body and trim materials.
 - 4) Body rating.
 - 5) Arrow indicating direction of flow.

2.4 GLOBE-STYLE CONTROL VALVES

A. General Requirements:

1. Body Dimensions: Comply with ISA 75.08.01.
2. Field Service: Construct the valves to be serviceable from the top with replaceable seats and plugs.
3. Field-Interchangeable Trim:
 - a. Cage Guided Valves: Available with field-interchangeable trim for different valve flow characteristics, such as equal percentage, linear, and quick opening.
 - b. Industrial Valves **NPS 1 (DN 25)** and Larger: Available with reduced trim one nominal size smaller.
4. Nameplate: Corrosion-resistant, indicating the following:
 - a. Manufacturer's name, model number, and serial number.
 - b. Body and trim size.
 - c. Arrow indicating direction of flow.

B. Globe Valves NPS 2 (DN 50) and Smaller, Two Way:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[IMI Hydronic Engineering Inc]**
 - c. **[Johnson Controls, Inc.]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[IMI Hydronic Engineering Inc]**
 - c. **[Johnson Controls, Inc.]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain two-way globe valves, **NPS 2 (DN 50)** and smaller, from single manufacturer.
4. Performance:
 - a. Stem Action: Linear stem travel.
 - b. Flow Characteristic: Equal percentage.
 - c. Leakage: **[FCI 70-2, Class VI][FCI 70-2, Class IV for brass trim][or][0.05 percent of maximum flow for stainless steel trim]<Insert leakage>**.
 - d. Hydronic Pressure:
 - 1) Rating: In accordance with ASME B16.15, Class 250.
 - 2) Close-off Pressure: Equal to pressure rating at maximum temperature.
 - 3) Pressure Differential (Maximum): **[30 psig (207 kPa) for sizes through NPS 2 (DN 50)][35 psig (207 kPa)]<Insert pressure>**.
 - e. Saturated Steam Pressure:

- 1) Rating: In accordance with ASME B16.15, Class 250.
 - 2) Close-off Pressure: Equal to pressure rating at maximum temperature.
 - 3) Pressure Differential (Maximum): **[15 psig (103 kPa) for control valves with brass trim][100 psig (689 kPa) for control valves with stainless steel trim]<Insert pressure>**.
- f. Ambient Operating Temperature: **35 to 150 deg F (2 to 65 deg C)**.
- g. Process Temperature Range:
- 1) Hydronic: **35 to 248 deg F (2 to 120 deg C)**.
 - 2) Steam: Temperature at saturated steam pressure.
- h. Rangeability: **[100]<Insert number>** to 1.
5. Construction:
- a. Size Range: **NPS 1/2 to NPS 2 (DN 13 to DN 50)**.
 - b. Body: Cast bronze or forged brass; ASME B16.15, Class 250.
 - c. End Connections: **[Female NPT threaded ends], [Unions with solder ends][Unions with threaded ends]**.
 - d. Bonnet: Bronze or brass, threaded.
 - e. Plug: Top guided.
 - f. Brass Trim:
 - 1) Packing: Self-adjusting Ethylene Propylene Rubber (EPR) rings or PTFE V-ring.
 - 2) Plug: Brass.
 - 3) Seat: Bronze or molded elastomeric disk.
 - 4) Stem: Stainless steel.
 - g. Stainless Steel Trim:
 - 1) Packing: PTFE V-ring.
 - 2) Plug: Stainless steel.
 - 3) Seat: Stainless steel.
 - 4) Stem: Stainless steel.
- C. Globe Valves NPS 2 (DN 50) and Smaller, Three Way:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Johnson Controls, Inc.]**
 - c. **[Siemens Industry, Inc., Building Technologies Division]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Johnson Controls, Inc.]**
 - c. **[Siemens Industry, Inc., Building Technologies Division]**
 - d. **<Insert manufacturer's name>**

3. Source Limitations: Obtain three-way globe valves, **NPS 2 (DN 50)** and smaller, from single manufacturer.
4. Performance:
 - a. Stem Action: Linear stem travel.
 - b. Flow Characteristic: Linear.
 - c. Leakage: **[FCI 70-2, Class VI][FCI 70-2, Class IV for brass trim][or][0.05 percent of maximum flow for stainless steel trim]<Insert leakage>**.
 - d. Hydronic Pressure:
 - 1) Rating: In accordance with ASME B16.15, Class 250.
 - 2) Close-off Pressure: Equal to pressure rating at maximum temperature.
 - 3) Pressure Differential (Maximum): **[30 psig (207 kPa) for sizes through NPS 2 (DN 50)][35 psig (207 kPa)]<Insert pressure>**.
 - e. Ambient Operating Temperature: **35 to 150 deg F (2 to 65 deg C)**.
 - f. Hydronic Process Temperature Range: **35 to 248 deg F (2 to 120 deg C)**.
 - g. Rangeability: **[25 to 1][100 to 1]<Insert rangeability>**.
5. Construction:
 - a. Size Range: **NPS 1/2 to NPS 2 (DN 13 to DN 50)**.
 - b. Body: Cast bronze or forged brass; ASME B16.15, Class 250.
 - c. End Connections: **[Female NPT threaded ends], [Unions with solder ends][Unions with threaded ends]**.
 - d. Bonnet: Bronze or brass, threaded.
 - e. Plug: Top guided.
 - f. Brass Trim:
 - 1) Packing: Self-adjusting Ethylene Propylene Rubber (EPR) rings or PTFE V-ring.
 - 2) Plug: Brass
 - 3) Seat: Bronze or molded elastomeric disk.
 - 4) Stem: Stainless steel.

D. Globe Valves NPS 2-1/2 to NPS 6 (DN 65 to DN 150), Two Way:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**

- d. [Johnson Controls, Inc.]
 - e. [Siemens Industry, Inc., Building Technologies Division]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain two-way globe valves, **NPS 2-1/2 to NPS 6 (DN 65 to DN 150)**, from single manufacturer.
4. Performance:
- a. Stem Action: Linear stem travel.
 - b. Flow Characteristic: **[Equal percentage][or][linear]**.
 - c. Leakage: **[FCI 70-2, Class IV][0.1 percent of maximum flow]<Insert leakage>**.
 - d. Hydronic Pressure:
 - 1) Rating: In accordance with ASME B16.1, **[Class 125][Class 250][or][Class 125 or 250 as required by application]**.
 - 2) Close-off Pressure: Equal to pressure rating.
 - 3) Pressure Differential (Maximum): **[25 psig (172 kPa)]<Insert pressure>**.
 - e. Hydronic Process Temperature: **[35 to 280 deg F (2 to 138 deg C)]<Insert temperature range>**.
 - f. Saturated Steam Pressure:
 - 1) Rating: In accordance with ASME B16.1, **[Class 125][Class 250][or][Class 125 or 250 as required by application]**.
 - 2) Close-off Pressure: Equal to pressure rating.
 - 3) Pressure Differential (Maximum): **[15 psig (689 kPa)]<Insert pressure>**.
 - g. Ambient Operating Temperature: **[0 to 150 deg F (Minus 18 to 65 deg C)]<Insert temperature range>**.
 - h. Rangeability: **[10 to 1][50 to 1][85 to 1][100 to 1]<Insert rangeability>**.
5. Construction:
- a. Size Range: **NPS 2-1/2 to NPS 6 (DN 65 to DN 150)**.
 - b. Body: Cast iron; ASME B16.1.
 - c. End Connections: Flanged; suitable for mating to ASME B16.5 flanges.
 - d. Bonnet: Cast iron; bolted.
 - e. Plug: Top or bottom guided.
 - f. Brass or Bronze Trim:
 - 1) Packing: EPT rings or PTFE V-ring.
 - 2) Plug: Brass or bronze.
 - 3) Seat: Brass or bronze.
 - 4) Stem: Stainless steel.
 - g. Stainless Steel Trim:
 - 1) Packing: PTFE V-ring.
 - 2) Plug: Stainless steel.
 - 3) Seat: Stainless steel.
 - 4) Stem: Stainless steel.
- E. Globe Valves **NPS 2-1/2 to NPS 6 (DN 65 to DN 150)**, Three Way:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain three-way globe valves, **NPS 2-1/2 to NPS 6 (DN 65 to DN 150)**, from single manufacturer.
4. Performance:
 - a. Stem Action: Linear stem travel.
 - b. Flow Characteristic: Linear.
 - c. Leakage: **[FCI 70-2, Class III][FCI 70-2, Class IV][0.01 percent of maximum flow]<Insert leakage>**.
 - d. Hydronic Pressure:
 - 1) Rating: In accordance with ASME B16.1, **[Class 125][Class 250][or][Class 125 or 250 as required by application]**.
 - 2) Close-off Pressure: Equal to pressure rating.
 - 3) Pressure Differential (Maximum): **[25 psig (172 kPa)]<Insert pressure>**.
 - e. Hydronic Process Temperature: **[35 to 280 deg F (2 to 138 deg C)]<Insert temperature range>**.
 - f. Ambient Operating Temperature: **[0 to 150 deg F (Minus 18 to 65 deg C)]<Insert temperature range>**.
 - g. Rangeability: **[10 to 1][50 to 1][100 to 1]<Insert rangeability>**.
5. Construction:
 - a. Size Range: **NPS 2-1/2 to NPS 6 (DN 65 to DN 150)**.
 - b. Body: Cast iron; ASME B16.1.
 - c. End Connections: Flanged; suitable for mating to ASME B16.5 flanges.
 - d. Bonnet: Cast iron; bolted.
 - e. Plug: Top or bottom guided.
 - f. Brass or Bronze Trim:
 - 1) Packing: EPT rings or PTFE V-ring.
 - 2) Plug: Brass or bronze.
 - 3) Seat: Brass or bronze.
 - 4) Stem: Stainless steel.

- g. Stainless Steel Trim:
 - 1) Packing: PTFE V-ring.
 - 2) Plug: Stainless steel.
 - 3) Seat: Stainless steel.
 - 4) Stem: Stainless steel.
- F. Industrial-Grade Globe Valves NPS 3/4 (DN 20) and Smaller, Two Way:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - b. **[Spence Engineering Company, Inc]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - b. **[Spence Engineering Company, Inc]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain two-way industrial-grade globe valves, **NPS 3/4 (DN 20)** and smaller, from single manufacturer.
 - 4. Performance:
 - a. Stem Action: Linear stem travel.
 - b. Flow Characteristic: **[Equal percentage][or][linear]**.
 - c. Leakage: FCI 70-2, **[Class IV][Class VI]**.
 - d. Hydronic Pressure:
 - 1) Rating: In accordance with ASME B16.15, Class 250.
 - 2) Close-off Pressure: Equal to pressure rating.
 - 3) Pressure Differential (Maximum): **[35 psig (207 kPa)][100 psig (689 kPa)]<Insert pressure>**.
 - e. Hydronic Process Temperature Range: **[0 to 400 deg F (Minus 18 to 204 deg C)]<Insert temperature range>**.
 - f. Saturated Steam Pressure:
 - 1) Rating: In accordance with ASME B16.15, Class 250.
 - 2) Close-off Pressure: Equal to pressure rating.
 - 3) Pressure Differential (Maximum): **[100 psig (689 kPa)]<Insert pressure>**.
 - g. Ambient Operating Temperature: **[Minus 20 to 150 deg F (Minus 29 to 65 deg C)]<Insert temperature range>**.
 - h. Rangeability: **[100 to 1]<Insert rangeability>**.
 - 5. Construction:

- a. Size Range: **NPS1/2 to NPS 3/4 (DN 15 to DN 20)**.
- b. Body: Bronze.
- c. End Connections: Female NPT threaded.
- d. Bonnet: Bronze; screwed or bolted.
- e. Packing: PTFE V-ring.
- f. Plug: Top or cage guided; balanced or unbalanced.
- g. Plug and Stem: Stainless steel.
- h. Seat: Stainless steel with PTFE insert.

G. Industrial-Grade Globe Valves NPS 1 (DN 25) and Larger, Two Way:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - b. **[Flowserve Corporation]**
 - c. **[Jordan Valve; Richards Industries Company]**
 - d. **[Spirax Sarco Limited]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - b. **[Flowserve Corporation]**
 - c. **[Jordan Valve; Richards Industries Company]**
 - d. **[Spirax Sarco Limited]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain two-way industrial-grade globe valves from single manufacturer.
4. Performance:
 - a. Stem Action: Linear stem travel.
 - b. Flow Characteristic: **[Equal percentage][Linear][or][quick opening]**.
 - c. Leakage: FCI 70-2, **[Class IV][Class V][Class VI]**.
 - d. Hydronic Pressure:
 - 1) Rating for Cast-Iron Body Valves: In accordance with ASME B16.1, Class 125 or 250, as required by application.
 - 2) Rating for Cast-Steel and Stainless Steel Body Valves: In accordance with ASME B16.34, Class 150 or 300, as required by application.
 - 3) Close-off Pressure: Equal to pressure rating.
 - 4) Pressure Differential (Maximum): **[35 psig (207 kPa)][100 psig (689 kPa)]<Insert pressure>**.
 - e. Hydronic Process Temperature: **[0 to 450 deg F (Minus 18 to 232 deg C)]<Insert temperature range>**.
 - f. Saturated Steam Pressure:
 - 1) Rating for Cast-Iron Valves: In accordance with ASME B16.1, Class 125 or 250, as required by application.
 - 2) Rating for Cast-Steel and Stainless Steel Valves: In accordance with ASME B16.34,

- Class 150 or 300, as required by application.
 - 3) Close-off Pressure: Equal to pressure rating.
 - 4) Pressure Differential (Maximum): **[100 psig (689 kPa)]<Insert pressure>**.
- g. Ambient Operating Temperature: **[Minus 20 to 150 deg F (Minus 29 to 65 deg C)]<Insert temperature range>**.
- h. Rangeability: **[50 to 1][100 to 1]<Insert rangeability>**.
- 5. Features:
 - a. Interchangeable, restricted-capacity and full-size trim.
 - b. Interchangeable, cage and plug styles for three different flow characteristics: equal percentage, linear and quick opening.
 - c. Trim options to prevent damage caused by cavitation where required by application.
- 6. Construction:
 - a. Size Range: **NPS 1 to NPS 30 (DN 50 to DN 750)**.
 - b. Body: Cast **[iron][carbon steel][or][stainless steel]**.
 - c. End Connections:
 - 1) NPS 2 (DN 50) and Smaller: Female NPT threaded or flanged suitable for mating to ASME B16.5 flanges.
 - 2) NPS 2-1/2 (DN 65) and Larger: Raised face flanges suitable for mating to ASME B16.5 or ASME B16.47 flanges.
 - d. Bonnet: Bolted, material to match body.
 - e. Packing: PTFE V-ring.
 - f. Plug: Cage guided and balanced.
 - g. Plug, Seat, Cage, and Stem: Stainless steel plug and seat with hardened facing, stainless steel cage and stem.
 - h. Stem: Thread and pin stem to plug; polished finish.

2.5 PRESSURE-INDEPENDENT CONTROL VALVES

A. Pressure-Independent Ball Valves NPS 2 (DN 50) and Smaller:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **[Griswold Controls, LLC]**
 - d. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**

- c. **[Griswold Controls, LLC]**
 - d. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain pressure-independent ball valves, **NPS 2 (DN 50)** and smaller, from single manufacturer.
4. Performance:
- a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Flow Characteristic: Equal percentage.
 - c. Leakage: Zero.
 - d. Hydronic Pressure Rating: **360 psig (2482 kPa)**.
 - e. Hydronic Close-off Pressure: **200 psig (1379 kPa)**.
 - f. Process Temperature Range: **Between 35 to 250 deg F (2 to plus 121 deg C)**.
 - g. Rangeability: 100 to 1.
5. Pressure Regulation: Control valve automatically adjusts to fluctuations in system pressure by one of the follow methods:
- a. Integral Mechanical Regulation: Maintains a constant pressure differential while operating within a pressure differential range of **[5 to 50 psig (34 to 345 kPa)]<Insert pressure range>**.
 - b. Integral Electronic Regulation: Electronic flow meter and control signal to maintain flow set point regardless of system pressure variations and modulates valve based on its measured true flow.
 - 1) Flow Measurement: Within 2 percent of actual reading.
 - 2) Flow Control: Within 5 percent of set point.
 - 3) Pressure Differential Range: **[5 to 50 psig (34 to 345 kPa)]<Insert pressure range>**.
6. Construction:
- a. Body: Bronze or forged brass[, **nickel plated**].
 - b. End Connections: Female threaded (NPT) ends.
 - c. Test Ports: Two pressure and temperature test ports positioned on valve body to read pressure differential.
 - d. Diaphragm: HNBR or EPDM.
 - e. Ball: Chrome-plated brass or stainless steel.
 - f. Seats: RTFE.
 - g. Stem and Stem Extension: Material to match ball; blowout-proof design.
 - h. Stem Seal: RTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.

B. Pressure-Independent Ball Valves NPS 2-1/2 to NPS 6 (DN 65 to DN 150):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**

- c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Bray Commercial]**
 - c. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain pressure-independent ball valves **NPS 2-1/2 to NPS 6 (DN 65 to DN 150)** from single manufacturer.
 - 4. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Flow Characteristic: Equal percentage.
 - c. Leakage: Zero.
 - d. Hydronic Pressure Rating: In accordance with ASME B16.1, Class 125 or 250, as required by application.
 - e. Hydronic Close-off Pressure:
 - 1) Class 125: **175 psig (1207 kPa)**.
 - 2) Class 250: **310 psig (2137 kPa)**.
 - f. Process Temperature Range: Between **35 to 250 deg F (2 to plus 121 deg C)**.
 - g. Rangeability: 100 to 1.
 - 5. Pressure Regulation: Control valve automatically adjusts to fluctuations in system pressure by one of the follow methods:
 - a. Integral Mechanical Regulation: Maintains a constant pressure differential while operating within a pressure differential range of **[5 to 50 psig (34 to 345 kPa)]<Insert pressure range>**.
 - b. Integral Electronic Regulation: Electronic flow meter and control signal to maintain flow set point regardless of system pressure variations and modulates valve based on its measured true flow.
 - 1) Flow Measurement: Within 2 percent of actual reading.
 - 2) Flow Control: Within 5 percent of set point.
 - 3) Pressure Differential Range: **5 to 50 psig (34 to 345 kPa)**.
 - 6. Construction:
 - a. Body: Cast iron; ASME B16.1.
 - b. End Connections: Flanged; suitable for mating to ASME B16.5 flanges.
 - c. Test Ports: Two pressure and temperature test ports positioned on valve body to read pressure differential.
 - d. Ball: Stainless steel.
 - e. Seats: RTFE.
 - f. Stem and Stem Extension: Material to match ball; blowout-proof design.
 - g. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.
- C. Pressure-Independent Globe Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bell & Gossett; a Xylem brand]**
 - b. **[Bray Commercial]**
 - c. **[Danfoss, Inc.]**
 - d. **[Flow Control Industries, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Siemens Industry, Inc., Building Technologies Division]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bell & Gossett; a Xylem brand]**
 - b. **[Bray Commercial]**
 - c. **[Danfoss, Inc.]**
 - d. **[Flow Control Industries, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Siemens Industry, Inc., Building Technologies Division]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain threaded end pressure-independent globe valves from single manufacturer.
4. Performance:
 - a. Stem Action: Linear stem travel.
 - b. Flow Characteristic: **[Equal percentage][or][linear]**.
 - c. Flow Control: Within 5 percent of set point.
 - d. Leakage: FCI 70-2, Class IV.
 - e. Hydronic Pressure Rating: **[250 psig (2482 kPa)][360 psig (2482 kPa)]<Insert pressure range>**.
 - f. Hydronic Close-off Pressure: **[90 psig (620 kPa)][140 psig (965 kPa)]<Insert pressure range>**.
 - g. Process Temperature Range: Between **35 to 240 deg F (2 to plus 115 deg C)**.
 - h. Rangeability: **[50]<Insert number>** to 1.
5. Pressure Regulation: Control valve automatically adjusts to fluctuations in system pressure by integral mechanical regulation to maintain a constant pressure differential while operating within a pressure differential range of **[5 to 60 psig (34 to 414 kPa)]<Insert pressure range>**.
6. Construction:
 - a. Size Range: **NPS 1/2 to NPS 2 (DN 13 to DN 50)**.
 - b. Body: Bronze or forged brass.
 - c. End Connections: Female threaded (NPT) ends.
 - d. Test Ports: Two pressure and temperature test ports positioned on valve body to read pressure differential.
 - e. Diaphragm: HNBR or EPDM.
 - f. O-Rings: EPDM.
 - g. Plug: Brass or stainless steel.
 - h. Spring: Stainless steel.
 - i. Stem: Stainless steel.

D. Pressure-Independent Globe Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Bell & Gossett; a Xylem brand]**
 - b. **[Bray Commercial]**
 - c. **[Danfoss, Inc.]**
 - d. **[Flow Control Industries, Inc.]**
 - e. **[Flowcon Americas LLC]**
 - f. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - g. **[IMI Hydronic Engineering Inc]**
 - h. **[Siemens Industry, Inc., Building Technologies Division]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bell & Gossett; a Xylem brand]**
 - b. **[Bray Commercial]**
 - c. **[Danfoss, Inc.]**
 - d. **[Flow Control Industries, Inc.]**
 - e. **[Flowcon Americas LLC]**
 - f. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - g. **[IMI Hydronic Engineering Inc]**
 - h. **[Siemens Industry, Inc., Building Technologies Division]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Obtain flanged end pressure-independent globe valves from single manufacturer.
4. Performance:
 - a. Stem Action: Linear stem travel.
 - b. Flow Characteristic: **[Equal percentage][or][linear]**.
 - c. Flow Control: Within 5 percent of set point.
 - d. Leakage: FCI 70-2, Class IV.
 - e. Hydronic Pressure Rating: **[175 psig (1207 kPa)][250 psig (2482 kPa)][360 psig (2482 kPa)]<Insert pressure range>**.
 - f. Hydronic Close-off Pressure: **[90 psig (620 kPa)]<Insert pressure range>**.
 - g. Process Temperature Range: Between **35 to 240 deg F (2 to plus 115 deg C)**.
 - h. Rangeability: **[50]<Insert number>** to 1.
5. Pressure Regulation: Control valve automatically adjusts to fluctuations in system pressure by integral mechanical regulation to maintain a constant pressure differential while operating within a pressure differential range of **[5 to 60 psig (34 to 414 kPa)]<Insert pressure range>**.
6. Construction:
 - a. Size Range: **[NPS 2-1/2 to NPS 6 (DN 65 to DN 150)][NPS 2-1/2 to NPS 10 (DN 65 to DN 250)]**.
 - b. Body: Cast iron or ductile iron.
 - c. End Connections: Flanged; suitable for mating to ASME B16.5 flanges.
 - d. Test Ports: Two pressure and temperature test ports positioned on valve body to read pressure differential.

- e. Diaphragm: HNBR or EPDM.
- f. O-Rings: EPDM.
- g. Plug: Brass or stainless steel.
- h. Spring: Stainless steel.
- i. Stem: Stainless steel.

2.6 SOLENOID VALVES

A. Brass and Bronze Solenoid Valves, Two Way:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ASCO; Emerson Electric Co., Automation Solutions]**
 - b. **[Danfoss, Inc.]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **[Sizto Tech Corporation (STC)]**
 - e. **[Velcor Engineering Corporation]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ASCO; Emerson Electric Co., Automation Solutions]**
 - b. **[Danfoss, Inc.]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **[Sizto Tech Corporation (STC)]**
 - e. **[Velcor Engineering Corporation]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain two-way brass and bronze solenoid valves from single manufacturer.
4. Performance:
 - a. Ambient Operating Temperature: **[32 to 125 deg F (0 to 52 deg C)]<Insert temperature range>**.
 - b. Leakage: Bubbletight.
 - c. Hydronic Operating Pressure:
 - 1) Maximum: **[125 psig (862 kPa)][150 psig (1034 kPa)][200 psig (1379 kPa)][300 psig (2068 kPa)]<Insert pressure>**.
 - 2) Minimum Operating: **[0 psig (0 kPa)][5 psig (34 kPa)]<Insert pressure>**.
 - d. Hydronic Process Temperature Range: **[0 to 250 deg F (Minus 18 to plus 120 deg C)]<Insert temperature range>**.
 - e. Saturated Steam Pressure: **[15 psig (103 kPa)][125 psig (862 kPa)]<Insert pressure>**.
 - f. Speed of Response: Manufacturer's **[standard design][or][slow-closing design to reduce potential water hammer]**.
 - g. Voltage: Coordinate with field power source.
5. Features:

- a. Action: Either normally open (open when de-energized) or normally closed (closed when de-energized), as required by the application.
 - b. Operation: Direct-acting or pilot-operated diaphragm or piston, as required by the application.
 - c. Override: Integral manual override.
6. Construction:
- a. Size Range: **NPS 1/2 to NPS 2 (DN 13 to DN 50)**.
 - b. Body: Brass or bronze.
 - c. End Connections: Female threaded (NPT) ends.
 - d. Discs and Seats: NBR, EPDM or PTFE.
 - e. Orifice: Select size for performance required by application.
 - f. Wetted Parts: Stainless steel.
 - g. Coil: Copper [or] **<Insert material>**.
 - h. Coil Insulation: **[Class F][or][Class H]**.
 - i. Solenoid Enclosure: NEMA 250, **[Type 4][or][Type 4X]<Insert type>**.

B. Stainless Steel Solenoid Valves, Two Way:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ASCO; Emerson Electric Co., Automation Solutions]**
 - b. **[Danfoss, Inc.]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **[Sizto Tech Corporation (STC)]**
 - e. **[Velcor Engineering Corporation]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ASCO; Emerson Electric Co., Automation Solutions]**
 - b. **[Danfoss, Inc.]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **[Sizto Tech Corporation (STC)]**
 - e. **[Velcor Engineering Corporation]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain two-way stainless steel solenoid valves from single manufacturer.
4. Performance:
 - a. Ambient Operating Temperature: **[32 to 125 deg F (0 to 52 deg C)]<Insert temperature range>**.
 - b. Leakage: Bubbletight.
 - c. Hydronic Operating Pressure:
 - 1) Maximum: **[125 psig (862 kPa)][150 psig (1034 kPa)][200 psig (1379 kPa)][300 psig (2068 kPa)]<Insert pressure>**.
 - 2) Minimum Operating: **[0 psig (0 kPa)][5 psig (34 kPa)]<Insert pressure>**.
 - d. Hydronic Process Temperature Range: **[0 to 250 deg F (Minus 18 to plus 120**

- deg C)]<Insert temperature range>.
 - e. Saturated Steam Pressure: [15 psig (103 kPa)][125 psig (862 kPa)]<Insert pressure>.
 - f. Speed of Response: Manufacturer's [standard design][or][slow-closing design to reduce potential water hammer].
 - g. Voltage: Coordinate with field power source.
5. Features:
- a. Action: Either normally open (open when de-energized) or normally closed (closed when de-energized), as required by the application.
 - b. Operation: Direct-acting or pilot-operated diaphragm or piston, as required by the application.
 - c. Override: Integral manual override.
6. Construction:
- a. Size Range: **NPS 1/2 to NPS 2 (DN 13 to DN 50)**.
 - b. Body: Stainless steel.
 - c. End Connections: Female threaded (NPT) ends.
 - d. Discs and Seats: NBR, EPDM, or PTFE.
 - e. Orifice: Select size for performance required by application.
 - f. Wetted Parts: Stainless steel.
 - g. Coil: Silver [or]<Insert material>.
 - h. Coil Insulation: [Class F][or][Class H].
 - i. Solenoid Enclosure: NEMA 250, [Type 4][or][Type 4X]<Insert type>.

2.7 SELF-CONTAINED TEMPERATURE-REGULATING VALVES

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- 1. [Jordan Valve; Richards Industries Company]
 - 2. [Spence Engineering Company, Inc]
 - 3. [Spirax Sarco Limited]
 - 4. [W.E. Anderson; a division of Dwyer Instruments, Inc.]
 - 5. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1. [Jordan Valve; Richards Industries Company]
 - 2. [Spence Engineering Company, Inc]
 - 3. [Spirax Sarco Limited]
 - 4. [W.E. Anderson; a division of Dwyer Instruments, Inc.]
 - 5. <Insert manufacturer's name>
- C. Source Limitations: Obtain self-contained temperature-regulating valves from single manufacturer.
- D. Description:
- 1. Self-contained and self-operated temperature-regulating valve. Direct acting or reverse acting, as required by application.
 - 2. Direct Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb,

forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn closing the fail-safe open valve.

3. Reverse Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn opening the fail-safe closed valve.

E. Performance:

1. Leakage: Comply with FCI 70-2, Class IV.
2. Hydronic Pressure:
 - a. Rating: [125 psig (862 kPa)][150 psig (1034 kPa)][200 psig (1379 kPa)][300 psig (2068 kPa)]<Insert pressure>.
 - b. Close-off: [Equal to rating]<Insert pressure>.
 - c. Differential: [5 psig (34 kPa)]<Insert pressure>.
3. Hydronic Process Temperature Range: Match to applications of up to [0 to 250 deg F (minus 18 to plus 120 deg C)]<Insert temperature range>.
 - a. Drains from Hot Equipment to Sanitary Sewer System: 105 to 140 deg F (40 to 60 deg C).
 - b. <Insert description of application>.
4. Saturated Steam Pressure: [15 psig (103 kPa)][125 psig (862 kPa)]<Insert pressure>.
5. Operating Range: Control flow from between [5]<Insert number> to 100 percent of rated capacity.
6. Sizing: Size to pass the design flow required with not more than 95 percent of the stem lift while operating at design pressure.

F. Features:

1. Interchangeable trim for one size smaller.
2. <Insert feature>.

G. Construction:

1. Size Range: NPS 1/2 to NPS 2 (DN 13 to DN 50).
2. Body: [Bronze][carbon steel][ductile iron][or][stainless steel].
3. End Connections: Female threaded (NPT) ends.
4. Trim: 300 series stainless steel.
5. Seats: 300 series stainless steel, PTFE.
6. Actuator Yoke: Aluminum, cast iron or carbon steel.
7. Capillary, Bulb, and Armor: [Copper][or][300 series stainless steel] bulb and capillary with stainless steel armor.
8. Thermal Fill Material: Match to the temperature range.
9. Thermowell: [Type 316 stainless steel][or]<Insert material> thermowell sized to fit the bulb and pipe.

2.8 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

- A. Manufacturers:** Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Asahi/America]
2. [Belimo Aircontrols (USA), Inc]

3. [Bray Commercial]
4. [Fischer; Emerson Electric Co., Automation Solutions]
5. [Flo-Tite, Inc.]
6. [Flowserve Corporation]
7. [Honeywell International Inc.]
8. [Jordan Valve; Richards Industries Company]
9. [Keystone; Emerson Electric Co., Automation Solutions]
10. [Max-Air Technology Inc.]
11. [Max-Seal, Inc.]
12. [Milwaukee Valve Company]
13. [NIBCO INC.]
14. [Spence Engineering Company, Inc]
15. [Spirax Sarco Limited]
16. [Valve Solutions, Inc.]
17. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Asahi/America]
2. [Belimo Aircontrols (USA), Inc]
3. [Bray Commercial]
4. [Fischer; Emerson Electric Co., Automation Solutions]
5. [Flo-Tite, Inc.]
6. [Flowserve Corporation]
7. [Honeywell International Inc.]
8. [Jordan Valve; Richards Industries Company]
9. [Keystone; Emerson Electric Co., Automation Solutions]
10. [Max-Air Technology Inc.]
11. [Max-Seal, Inc.]
12. [Milwaukee Valve Company]
13. [NIBCO INC.]
14. [Spence Engineering Company, Inc]
15. [Spirax Sarco Limited]
16. [Valve Solutions, Inc.]
17. <Insert manufacturer's name>

C. Furnish control valves with factory-installed actuators from control valve manufacturer. Actuators manufactured by listed control valve manufacturers are acceptable subject to compliance with requirements.

D. Actuators for Control Valves in Hydronic Systems: Select actuators to close off against system pump shutoff head.

E. Actuators for Control Valves in Steam Systems: Select actuators to close off against [1.1][1.2][1.5]<Insert number> times steam design pressure.

F. Type: Motor operated, with or without gears, electric and electronic.

G. Voltage:

1. [See Drawings][Voltage selection is delegated to professional designing control system][24 V][120 V]<Insert requirement>.
2. Actuator to deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

3. Actuator to function properly within a range of [85]<Insert number> to [120]<Insert number> percent of nameplate voltage.
- H. Construction:
1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
 2. 100 up to 400 W: Ground steel gears, oil immersed; shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains are to be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
 3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- I. Local Field Adjustment: Make spring-return actuators easily switchable from fail-safe open to fail-safe closed in the field without replacement.
- J. Local Manual Override: Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.
- K. Two-Position Actuators: Single direction, spring-return or reversing type.
- L. Modulating Actuators:
1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
 2. Control Input Signal:
 - a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
 - b. Proportional: Actuator drives proportionally to input signal, modulates throughout its angle of rotation, and is suitable for [zero to 10][or][2 to 10] V dc [and][4 to 20 mA] signals.
 - c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink, or source controller.
 - d. Programmable Multifunction:
 - 1) Control input, position feedback, and running time are to be factory or field programmable.
 - 2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
 - 3) Service data, including at a minimum, number of hours powered and number of hours in motion.
- M. Position Feedback:
1. [Equip][Where indicated, equip] two-position actuators with limit switches or other positive means of a position indication signal for remote monitoring of [open][and][close] position.
 2. [Equip][Where indicated, equip] modulating actuators with a position feedback through [current][or][voltage] signal for remote monitoring.
 3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
- N. Fail-Safe:
1. Where indicated, provide actuator to fail to an end position.
 2. Internal spring-return mechanism to drive controlled device to an end position (open or close) on

loss of power.

3. Batteries, capacitors, and other nonmechanical forms of fail-safe operation are acceptable only where uniquely indicated.

O. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

P. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve stem without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

Q. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of [minus 20 to plus 120 deg F (minus 29 to plus 49 deg C)]<Insert temperature range>.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range is to be from [5 to 95]<Insert numbers> percent relative humidity, noncondensing.

R. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, [Type 2][or][Type 4] for indoor and protected applications.
3. NEMA 250, [Type 4][or][Type 4X] for outdoor and unprotected applications.
4. NEMA 250, [Type 7][or][Type 9] for hazardous applications requiring explosion-proof construction.
5. Provide actuator enclosure with a heater and controller where required by application.

S. Stroke Time:

1. Select operating stroke time to be compatible with equipment and system operation[, and as follows:][.]
 - a. Operate valve from fully closed to fully open position within [15][30][60][75][90][150]<Insert number> seconds.
 - b. Operate valve from fully open to fully closed position within [15][30][60][75][90][150]<Insert number> seconds.
 - c. Move valve to fail-safe position within [5][15][30]<Insert number> seconds.

T. Sound: Where actuators are located in tenant-occupied rooms with a room sound level criteria of [NC-35]<Insert NC level> or lower, comply with the following sound levels:

1. Spring Return: [45]<Insert number>dBA.
2. Nonspring Return: [45]<Insert number> dBA.

2.9 PNEUMATIC CONTROL VALVE ACTUATORS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Asahi/America]**
 2. **[Bray Commercial]**
 3. **[Fischer; Emerson Electric Co., Automation Solutions]**
 4. **[Flo-Tite, Inc.]**
 5. **[Flowserve Corporation]**
 6. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 7. **[Johnson Controls, Inc.]**
 8. **[Jordan Valve; Richards Industries Company]**
 9. **[Keystone; Emerson Electric Co., Automation Solutions]**
 10. **[Max-Air Technology Inc.]**
 11. **[Max-Seal, Inc.]**
 12. **[Milwaukee Valve Company]**
 13. **[NIBCO INC.]**
 14. **[Siemens Industry, Inc., Building Technologies Division]**
 15. **[Spence Engineering Company, Inc]**
 16. **[Spirax Sarco Limited]**
 17. **[Valve Solutions, Inc.]**
 18. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Asahi/America]**
 2. **[Bray Commercial]**
 3. **[Fischer; Emerson Electric Co., Automation Solutions]**
 4. **[Flo-Tite, Inc.]**
 5. **[Flowserve Corporation]**
 6. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 7. **[Johnson Controls, Inc.]**
 8. **[Jordan Valve; Richards Industries Company]**
 9. **[Keystone; Emerson Electric Co., Automation Solutions]**
 10. **[Max-Air Technology Inc.]**
 11. **[Max-Seal, Inc.]**
 12. **[Milwaukee Valve Company]**
 13. **[NIBCO INC.]**
 14. **[Siemens Industry, Inc., Building Technologies Division]**
 15. **[Spence Engineering Company, Inc]**
 16. **[Spirax Sarco Limited]**
 17. **[Valve Solutions, Inc.]**
 18. **<Insert manufacturer's name>**
- C. Source Limitations:
1. Furnish control valves with factory-installed actuators by control valve manufacturer. Actuators manufactured by listed control valve manufacturers are acceptable subject to compliance with requirements.
- D. Actuators for Control Valves in Hydronic Systems: Select actuators to close off against system pump shutoff head.

- E. Actuators for Control Valves in Steam Systems: Select actuators to close off against **[1.1][1.2][1.5]<Insert number>** times steam design pressure.
- F. Equip pneumatic modulating actuators with a positive positioner, having the following performance characteristics:
 - 1. Linearity: Within **[1]<Insert number>** percent of output signal span.
 - 2. Hysteresis: **[0.5]<Insert value>** percent of the span.
- G. Provide each positioner with an integrally mounted air set and pressure gauges for supply, input, and output. Operate on a **3 to 15 psig (21 to 103 kPa)** input signal unless otherwise required by the application to comply with the control sequence of operation.
- H. Rate actuators for a pressure of at least **[1.1]<Insert value>** times main supply air pressure to actuator, but not less than **[25 psig (172 kPa)]<Insert pressure>**.
- I. Single-Action (Spring-Return) Diaphragm Actuators:
 - 1. Travel: As required by application.
 - a. Rotary travel for control of quarter-turn (0 to 90 degrees) control valves.
 - b. Linear travel for control valves with linear stem travel.
 - 2. Fail-Safe Position (Loss of Air): Air-to-open or air-to-close, as required by application.
 - 3. Construction:
 - a. Diaphragm: Reinforced synthetic rubber or nitrile. Provide actuators with replaceable diaphragms **[where indicated for the application]**.
 - b. Diaphragm Casing and Plate: Cast iron, steel, or cast aluminum.
 - c. Spring, stem, and spring adjuster: Steel or steel alloy.
 - d. Yoke: Cast iron, steel, or cast aluminum.
- J. Double-Action (Air-to-Air) Rack-and-Pinion Actuators:
 - 1. Travel: Rotary travel for control of quarter-turn (0 to 90 degrees) valves.
 - 2. Fail-Safe Position (Loss of Air): Last position.
 - 3. Construction:
 - a. Body: Anodized extruded-aluminum alloy.
 - b. End Caps: Cast-aluminum alloy.
 - c. Pistons: Cast-aluminum alloy.
 - d. Piston O-Ring Seals: NBR.
 - e. Output Shaft and Pinion: Zinc-plated carbon steel or stainless steel.
 - f. Travel Stops: Adjustable, stainless steel.
 - g. Fasteners: Stainless steel.
- K. Single-Action (Spring-Return) Rack-and-Pinion Actuators:
 - 1. Travel: Rotary travel for control of quarter-turn (0 to 90 degrees) control valves.
 - 2. Fail-Safe Position (Loss of Air): Air-to-open or air-to-close, as required by application.
 - 3. Construction:
 - a. Body: Anodized extruded-aluminum alloy.
 - b. End Caps: Cast-aluminum alloy.
 - c. Pistons: Cast-aluminum alloy.

- d. Piston O-Ring Seals: NBR.
 - e. Output Shaft and Pinion: Zinc-plated carbon steel or stainless steel.
 - f. Springs: **[Coated]**steel or steel alloy.
 - g. Travel Stops: Adjustable, stainless steel.
 - h. Fasteners: Stainless steel.
- L. Provide actuator with adjustable stops for both maximum and minimum positions.
- M. Local Manual Override: Where indicated, provide actuators with an external manual adjustment mechanism to allow manual positioning of the valve through the actuator.
- N. Local Position Indication: Provide a position indicator and graduated scale on each actuator. Indicate open and closed travel limits.
- O. Enclosure:
- 1. Suitable for ambient conditions encountered by application.
 - 2. Install actuator(s) in a supplemental enclosure with a heater and controller where required by application.
- P. Position Feedback Signal:
- 1. **[Equip][Where indicated, equip]** two-position actuators with limit switches or other positive means of a position indication signal for remote monitoring of **[open][and][close]** position.
 - 2. **[Equip][Where indicated, equip]** modulating actuators with a position feedback through **[current][or][voltage]** signal for remote monitoring.
- Q. Stroke Time:
- 1. Select operating stroke time to be compatible with equipment and system operation[, **and as follows**].
 - a. Operate valve from fully closed to fully open position within **[15][30]<Insert number>** seconds.
 - b. Operate valve from fully open to fully closed position within **[15][30]<Insert number>** seconds.
 - c. Move valve to fail-safe position within **[5][15][30]<Insert number>** seconds.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL VALVE APPLICATIONS

A. Control Valves:

1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
2. <Insert system> System, <Insert unique application>, Two-Way Applications Controlled by Flow: [Ball valves][Ball valves with characterized disk][Ball valves with segmented ball][Ball valves with full ball and characterized V-notch][Pressure-independent valves][Butterfly valves][High-performance butterfly valves][Globe valves][Industrial-grade globe valves][Solenoid valves].
3. <Insert system> System, <Insert unique application>, Two-Way Applications Controlled by Pressure: [Ball valves][Ball valves with characterized disk][Ball valves with segmented ball][Ball valves with full ball and characterized V-notch][Pressure-independent valves][Butterfly valves][High-performance butterfly valves][Globe valves][Industrial-grade, globe valves][Solenoid valves].
4. <Insert system> System, <Insert unique application>, Two-Way Applications Controlled by Temperature: [Ball valves][Ball valves with characterized disk][Ball valves with segmented ball][Ball valves with full ball and characterized V-notch][Pressure-independent valves][Butterfly-style valves][High-performance butterfly valves][Globe valves][Industrial-grade globe valves][Solenoid valves][Self-contained temperature-regulating valves].
5. <Insert system> System, <Insert unique application>, Three Way, Controlled by Temperature: [Ball valves][Ball valves with characterized disk][Ball valves with segmented][Butterfly-style valves][Globe valves].
6. Steam System, <Insert unique application>, Two Way, Controlled by Temperature: [Ball valves][Ball valves with segmented ball][Ball valves with full ball and characterized V-notch][Globe valves][Industrial-grade globe valves][Solenoid valves][Self-contained temperature-regulating valves].

3.3 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support control valves and actuators, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic event, wind, or other forces common to the application.
- D. Provide ceiling, floor, roof, and wall openings [and sleeves]required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- E. Seal penetrations made in fire-rated and acoustically rated assemblies.
- F. Fastening Hardware:
 1. Wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- G. Install products in locations that are accessible and that will permit calibration and maintenance from

floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. Use Type 316 stainless steel tubing and fittings when in contact with a corrosive environment.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 CONTROL VALVES

A. Install pipe reducers for control valves smaller than line size. Position reducers as close to control valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Drain Valves:

1. Install drain valves in piping upstream and downstream of each control valve larger than [NPS 2 (DN 50)][NPS 4 (DN 100)]<Insert pipe size>.
2. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold.

D. Test Plugs: Install pressure temperature test plugs in piping upstream and downstream of each control valve[larger than]<Insert pipe size>.

E. Three-Valve Bypass Manifold: Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing isolation valves in inlet and discharge piping of control valve and a manual throttling valve in bypass pipe.

1. <Insert applications>.

F. Valve Orientation:

1. Where possible, install [ball][and][globe] valves that are installed in horizontal piping, with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping, with stems in horizontal position and with low point of disc opening with direction of flow.

G. Clearance:

1. Locate valves for easy access, and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least [12 inches (300 mm)]<Insert distance> of clear space around valve and between valves and adjacent surfaces.

H. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

I. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt-tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Use same designation at each end for each piece of wire, cable, and tubing for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with valve identification on valve[**and on face of ceiling directly below valves concealed above ceilings**]. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

3.6 ELECTRICAL CONNECTIONS

- A. Install electrical power to field-mounted control devices requiring electrical power.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260523 "Control-Voltage Electrical Power Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.7 CONTROL CONNECTIONS

- A. Pneumatic Control Connections: Connect pneumatic control valve actuators and accessories to pneumatic main and signal air. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- B. Install control signal wiring to field-mounted control devices.
- C. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.8 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.9 STARTUP

- A. Control Valve Checkout:
 - 1. Check installed products before continuity tests, leak tests, and calibration.
 - 2. Check valves for proper location and accessibility.
 - 3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
 - 4. For pneumatic products, verify air supply for each product is properly installed.
 - 5. For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner.
 - 6. Verify that control valves are installed correctly for flow direction.
 - 7. Verify that valve body attachment is properly secured and sealed.
 - 8. Verify that valve actuator and linkage attachment are secure.
 - 9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
 - 10. Verify that valve ball, disc, and plug travel are unobstructed.
 - 11. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. Stroke pneumatic control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.
- C. Check and document open and close cycle times for applications with a cycle time of less than [15]<Insert time> seconds.
- D. For control valves equipped with positive position indication, check feedback signal at multiple positions



to confirm proper position indication.

END OF SECTION 23 09 23 11



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 23 11	23 09 23 00	Direct Digital Control (DDC) System for HVAC
23 09 23 11	23 09 23 00a	Leak Detection Instruments
23 09 23 11	23 09 23 00b	Position Instruments
23 09 23 11	23 09 00 00	Speed Instruments
23 09 23 11	23 09 23 00c	Sequence of Operations for HVAC DDC



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 09 23 12 - CONTROL DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular control dampers with airfoil blades.
2. Rectangular control dampers with flat blades.
3. Rectangular control dampers with insulated blades.
4. Rectangular control dampers with integral airflow monitoring.
5. Rectangular control dampers with integral airflow control.
6. Rectangular industrial-duty control dampers.
7. Round control dampers.
8. Round industrial-duty control dampers.
9. Electric and electronic control-damper actuators.
10. Pneumatic control-damper actuators.

B. Related Requirements:

1. Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 DEFINITIONS

- A. DDC:** Direct digital control.
- B. RMS:** Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
- C. Thermal Efficiency Ratio (E):** Comparison of a tested damper's thermal performance against a v-groove blade reference damper. A damper with the same thermal efficiency as the reference damper would have an E value of 0 percent, while a damper that is 4 times as efficient would have an E value of 200 percent.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Rectangular control dampers with airfoil blades.
2. Rectangular control dampers with flat blades.
3. Rectangular control dampers with insulated blades.
4. Rectangular control dampers with integral airflow monitoring.
5. Rectangular control dampers with integral airflow control.
6. Rectangular industrial-duty control dampers.
7. Round control dampers.
8. Round industrial-duty control dampers.



9. Electric and electronic control-damper actuators.
10. Pneumatic control-damper actuators.

B. Product Data Submittals: For each damper and actuator.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

C. Shop Drawings:

1. Include plans, elevations, sections, and [**mounting**] details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for pneumatic signal and main air tubing.

D. Delegated Design Submittals:

1. Schedule and design calculations for control dampers and actuators, including the following:
 - a. Unique designation for each damper/actuator assembly.
 - b. Service/application.
 - c. Damper assembly size.
 - d. Damper assembly weight, including actuator(s).
 - e. Damper and actuator action (modulating or two position).
 - f. Flow at project design and minimum flow conditions.
 - g. Face velocity at project design and minimum airflow conditions.
 - h. Pressure drop across damper at project design and minimum airflow conditions.
 - i. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
 - j. Maximum close-off pressure.
 - k. Leakage airflow at maximum system pressure differential (fan close-off pressure).
 - l. Damper torque required at worst-case condition for sizing actuator.
 - m. Actuator selection indicating torque provided.
 - n. Actuator fail-safe position on loss of power and loss of signal.
 - o. Remarks listing special requirements.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are indicated and coordinated with each other, using input from installers of the items involved:

1. Product installation location indicated in relationship to room, duct, and equipment.
2. Size and location of wall access panels for control dampers and actuators installed behind walls.
3. Size and location of ceiling access panels for control dampers and actuators installed above inaccessible ceilings.



1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control dampers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE 62.1 Compliance: Applicable outdoor ventilation requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- D. Code Compliance: Comply with governing energy code.
- E. Delegated Design: Engage a qualified professional[**engineer**], as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.
- F. Ground Fault: Properly ground products to prevent failing due to ground fault conditions.
- G. Backup Power Source: Serve control-damper actuators from a backup power source where associated with systems and equipment served by a backup power source.
- H. Environmental Conditions: For actuators not available with integral enclosures complying with requirements indicated, house in protective secondary enclosures complying with requirements.
- I. Selection Criteria:
 - 1. Multi-Blade Damper Configuration: **[See Drawings][As follows unless otherwise indicated on Drawings]**:
 - a. Two-Position Control: **[Opposed][or][parallel]**.
 - b. Equipment Isolation Applications: **[Opposed][or][parallel]**.
 - c. Face and Bypass Applications: **[Opposed][or][parallel]**.
 - d. Outdoor/Return Air-Mixing Applications: **[Opposed][or][parallel]**.
 - e. All Other Applications: **[Opposed][or][parallel]**.
 - f. **<Insert application>**.
 - 2. Pressure and Temperature: Control dampers suitable for operating conditions encountered by the application **[and following conditions unless otherwise indicated on Drawings]**:
 - a. Supply Air: **<Insert pressure and coincident temperature requirements>**.
 - b. Return Air: **<Insert pressure and coincident temperature requirements>**.
 - c. Outdoor Air: **<Insert pressure and coincident temperature requirements>**.
 - d. Mixed Air: **<Insert pressure and coincident temperature requirements>**.
 - e. Exhaust Air: **<Insert pressure and coincident temperature requirements>**.
 - f. **<Insert system and requirements>**.
 - 3. Fail-Safe Positions: **[See Drawings][As follows unless otherwise indicated on Drawings]**:

- a. Supply Air: **[Close][Last position][Open]**.
 - b. Return Air: **[Close][Last position][Open]**.
 - c. Outdoor Air: **[Close][Last position][Open]**.
 - d. Mixed Air: **[Close][Last position][Open]**.
 - e. Exhaust Air: **[Close][Last position][Open]**.
 - f. **<Insert system and requirements>**.
4. Select dampers with smooth and stable operation throughout full range of operation over varying pressures and temperatures encountered.
 5. Sizing: **[See Drawings][As follows unless otherwise indicated on Drawings]**
 - a. Modulating Dampers: Select damper size for a pressure drop of **<Insert number>** percent of fan total static pressure unless otherwise indicated.
 - b. Two-Position Dampers: Full size of duct or equipment connection unless otherwise indicated.
 6. Pneumatic, Two-Position Control-Damper Opening and Closing Characteristic:
 - a. Provide a smooth opening and closing characteristic slow enough to avoid an excessive rapid change in system pressure.
 - b. Provide an adjustable opening time (full closed to full open) and an adjustable closing time (full open to full closed) ranging from zero to **[10][15][30]<Insert value>** seconds. Make opening and closing times independently adjustable.
 7. Pneumatic Control Signal Distance Limitation: Not to exceed **[100 ft. (30 m)][200 ft. (60 m)]<Insert distance>** from controller. For longer distances, provide an electric/electronic control signal to the damper/actuator and an electric solenoid valve or electro-pneumatic transducer locally at the damper/actuator to convert the control signal to pneumatic.

2.2 RECTANGULAR CONTROL DAMPERS WITH AIRFOIL BLADES

A. General Requirements:

1. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
 - a. Include multisection damper assemblies with intermediate reinforcing where required between individual sections being joined together. Construct reinforcing of same material (aluminum, galvanized steel, stainless steel) as damper frame.
2. Factory install actuator(s) as integral part of damper assembly. Coordinate, with damper manufacturer, field requirements for actuators, such as type, fail-safe position, power supply, location, and mounting requirements.

B. Rectangular Control Dampers with Aluminum Airfoil Blades and Frames:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**

- d. [Johnson Controls, Inc.]
 - e. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - f. [TAMCO (T. A. Morrison & Co. Inc.)]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [American Warming and Ventilating (AWV); Mestek, Inc.]
 - b. [Arrow United Industries; Mestek, Inc.]
 - c. [Greenheck Fan Corporation]
 - d. [Johnson Controls, Inc.]
 - e. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - f. [TAMCO (T. A. Morrison & Co. Inc.)]
 - g. <Insert manufacturer's name>
3. Source Limitations: Obtain rectangular control dampers, with aluminum airfoil blades and frames, from single manufacturer.
4. **[AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance and air leakage.]**
5. Performance:
- a. Leakage:
 - 1) AMCA 511, Class 1A, at **1 in. wg (250 Pa)** Differential Static Pressure: Leakage not to exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1 in. wg (250 Pa)** differential static pressure when tested in accordance with AMCA 500D.
 - 2) AMCA 511, Class 1, at **4 in. wg (1000 Pa)** Differential Static Pressure: Leakage not to exceed **8 cfm/sq. ft. (40.6 L/s per sq. m)** against **4 in. wg (1000 Pa)** differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: **[0.05 in. wg (12.5 Pa)]<Insert pressure drop>** at **[1500 fpm (7.6 m/s)]<Insert velocity>** across a **[24-by-24-inch (600-by-600-mm)]<Insert size>** damper when tested in accordance with AMCA 500D, figure **[5.3]<Insert figure no.>**.
 - c. Pressure Rating: Damper close-off pressure equal to **[fan shutoff pressure]<Insert requirement>** with a maximum blade deflection of **[1/180]<Insert deflection>** of blade length.
 - d. Temperature: **[Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)]<Insert temperature range>**.
 - e. Velocity: Up to **[4000 fpm (20 m/s)][6000 fpm (30 m/s)]<Insert velocity>**.
6. Construction:
- a. Frame:
 - 1) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, minimum **[0.125 inch (3 mm)]<Insert thickness>** thick.
 - 2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert size>** for attachment to duct flanges, plenum walls, and equipment.
 - 3) Width: Not less than **[5 inches (125 mm)]<Insert width>**.
 - b. Blades:
 - 1) Configuration: Parallel or opposed blade configuration as required by application.

- 2) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, [0.07 inch (1.8 mm)]<Insert thickness> thick.
 - 3) Shape: Hollow, airfoil.
 - 4) Length: As required by close-off pressure rating, not to exceed [48 inches (1200 mm)]<Insert length>.
 - 5) Width: Not to exceed [6 inches (150 mm)]<Insert width>.
- c. Seals:
- 1) Blades: Replaceable; extruded Santoprene, silicone, [or damper manufacturer-offered equivalent], as required by performance requirements. Seals are mechanically attached in extruded blade slots.
 - 2) Jams: Replaceable; stainless steel, compression type [or mechanically attached extruded silicone].
- d. Axles:
- 1) Diameter: Minimum [0.375 inch (10 mm)][0.5 inch (13 mm)]<Insert diameter>.
 - 2) Material: [Aluminum,][plated steel][or][stainless steel][, specific to application indicated].
 - 3) Mechanically attached to blades.
- e. Bearings:
- 1) Material: Molded [acetal][Celcon/polycarbonate][nylon][synthetic][or] stainless steel sleeve, as required by operating conditions, mounted in frame.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
- f. Linkage:
- 1) Hardware: [Plated][or][stainless] steel.
 - 2) Material: [Aluminum,][plated steel][or][stainless steel][, specific to application indicated].
 - 3) Mounting: Concealed in frame.
- g. Transitions with Sleeve:
- 1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connections.
 - 2) Factory mount damper in a sleeve with a close transition to mate to field connection.
 - a) Sleeve length not less than [12 inches (300 mm)]<Insert length> for dampers without jackshafts and not less than [16 inches (450 mm)]<Insert length> for dampers with jackshafts.
 - b) Oversize damper and sleeve for duct connection size plus minimum [4 inches (100 mm)]<Insert dimension>.
 - 3) Fabricate sleeve and transitions of materials (aluminum, galvanized steel or stainless steel) to match damper frame [or adjoining duct].
 - 4) Match end connections (flange or sleeve) to field connections.
- h. Additional Corrosion Protection for Corrosive Environments:
- 1) Provide anodized finish, minimum of 0.0007 inch (0.018 mm) thick, for aluminum surfaces in contact with airstream.

- 2) Paint surfaces exposed to airstream with an [enamel][or][epoxy]<Insert finish> finish. Prepare surfaces to be painted according to paint manufacturer's instructions.
- 3) Construct axles, damper linkage, and hardware of Type 316L stainless steel.

C. Rectangular Control Dampers with Galvanized-Steel Airfoil Blades and Frames:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Warming and Ventilating (AWV); Mestek, Inc.]
 - b. [Arrow United Industries; Mestek, Inc.]
 - c. [Greenheck Fan Corporation]
 - d. [Johnson Controls, Inc.]
 - e. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Warming and Ventilating (AWV); Mestek, Inc.]
 - b. [Arrow United Industries; Mestek, Inc.]
 - c. [Greenheck Fan Corporation]
 - d. [Johnson Controls, Inc.]
 - e. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain rectangular control dampers, with galvanized-steel airfoil blades and frames, from single manufacturer.
4. **[AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance and air leakage.]**
5. Performance:
 - a. Leakage:
 - 1) AMCA 511, Class 1A, at 1 in. wg (250 Pa) Differential Static Pressure: Leakage not to exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1 in. wg (250 Pa) differential static pressure when tested in accordance with AMCA 500D.
 - 2) AMCA 511, Class 1, at 4 in. wg (1000 Pa) Differential Static Pressure: Leakage not to exceed 8 cfm/sq. ft. (40.6 L/s per sq. m) against 4 in. wg (1000 Pa) differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: [0.06 in. wg (15 Pa)]<Insert pressure drop> at [1500 fpm (7.6 m/s)]<Insert velocity> across a [24-by-24-inch (600-by-600-mm)]<Insert size> damper when tested in accordance with AMCA 500D, figure [5.3]<Insert figure no.>.
 - c. Pressure Rating: Damper close-off pressure equal to [fan shutoff pressure]<Insert requirement> with a maximum blade deflection of [1/180]<Insert deflection> of blade length.
 - d. Temperature: [Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)]<Insert temperature range>.
 - e. Velocity: Up to [4000 fpm (20 m/s)][6000 fpm (30 m/s)]<Insert velocity>.
6. Construction:

- a. Frame:
 - 1) Material: ASTM A653/A653M galvanized steel, minimum [0.06 inch (1.6 mm)]<Insert thickness> thick.
 - 2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert size> for attachment to duct flanges, plenum walls, and equipment.
 - 3) Width: Not less than [5 inches (125 mm)]<Insert width>.
- b. Blades:
 - 1) Configuration: Parallel or opposed blade configuration as required by application.
 - 2) Material: ASTM A653/A653M galvanized steel, [0.05 inch (1.3 mm)]<Insert thickness> thick.
 - 3) Shape: Hollow, airfoil.
 - 4) Length: As required by close-off pressure rating, not to exceed [48 inches (1200 mm)]<Insert length>.
 - 5) Width: Not to exceed [8 inches (200 mm)]<Insert width>.
- c. Seals:
 - 1) Blades: Replaceable; extruded silicone, vinyl, [or damper manufacturer-offered equivalent], as required by performance requirements. Seals are to be mechanically attached in extruded blade slots.
 - 2) Jambs: Stainless steel, compression type.
- d. Axles:
 - 1) Diameter: Minimum [0.375 inch (10 mm)][0.5 inch (13 mm)]<Insert diameter>.
 - 2) Material: [Plated steel][or][stainless steel][, specific to application indicated].
 - 3) Mechanically attached to blades.
- e. Bearings:
 - 1) Material: Molded [acetal][nylon][or] stainless steel sleeve, as required by operating conditions, mounted in frame.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
- f. Linkage:
 - 1) Hardware: [Plated][or][stainless] steel.
 - 2) Material: [Plated steel][or][stainless steel][, specific to application indicated].
 - 3) Mounting: Concealed in frame.
- g. Transitions with Sleeve:
 - 1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connections.
 - 2) Factory mount damper in a sleeve with a close transition to mate to field connection.
 - a) Sleeve length not less than [12 inches (300 mm)]<Insert length> for dampers without jackshafts and not less than [16 inches (450 mm)]<Insert length> for dampers with jackshafts.
 - b) Oversize damper and sleeve for duct connection size plus minimum [4 inches (100 mm)]<Insert dimension>.

- 3) Fabricate sleeve and transitions of galvanized steel.
 - 4) Match end connections (flange or sleeve) to field connections.
 - h. Additional Corrosion Protection for Corrosive Environments:
 - 1) Paint surfaces exposed to airstream with an [enamel][or][epoxy]<Insert finish> finish. Prepare surfaces to be painted according to paint manufacturer's instructions.
- D. Rectangular Control Dampers with Stainless Steel Airfoil Blades and Frames:
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow United Industries; Mestek, Inc.]
 - b. [Greenheck Fan Corporation]
 - c. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow United Industries; Mestek, Inc.]
 - b. [Greenheck Fan Corporation]
 - c. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - d. <Insert manufacturer's name>
 3. Source Limitations: Obtain rectangular control dampers, with stainless steel airfoil blades and frames, from single manufacturer.
 4. [AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance and air leakage.]
 5. Performance:
 - a. Leakage:
 - 1) AMCA 511, Class 1A, at 1 in. wg (250 Pa) Differential Static Pressure: Leakage not to exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1 in. wg (250 Pa) differential static pressure when tested in accordance with AMCA 500D.
 - 2) AMCA 511, Class 1, at 4 in. wg (1000 Pa) Differential Static Pressure: Leakage not to exceed 8 cfm/sq. ft. (40.6 L/s per sq. m) against 4 in. wg (1000 Pa) differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: [0.06 in. wg (15 Pa)]<Insert pressure drop> at [1500 fpm (7.6 m/s)]<Insert velocity> across a [24-by-24-inch (600-by-600-mm)]<Insert size> damper when tested in accordance with AMCA 500D, figure [5.3]<Insert figure no.>.
 - c. Pressure Rating: Damper close-off pressure equal to [fan shutoff pressure]<Insert requirement> with a maximum blade deflection of [1/180]<Insert deflection> of blade length.
 - d. Temperature: [Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)]<Insert temperature range>.
 - e. Velocity: Up to [4000 fpm (20 m/s)]<Insert velocity>.
 6. Construction:

- a. Frame:
 - 1) Material: Type 304 stainless steel, minimum [0.06 inch (1.6 mm)]<Insert thickness> thick.
 - 2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert size> for attachment to duct flanges, plenum walls, and equipment.
 - 3) Width: Not less than [5 inches (125 mm)]<Insert width>.
- b. Blades:
 - 1) Configuration: Parallel or opposed blade configuration as required by application.
 - 2) Material: Type 304 stainless steel, [0.05 inch (1.3 mm)]<Insert thickness> thick.
 - 3) Shape: Hollow, airfoil.
 - 4) Length: As required by close-off pressure rating, not to exceed [48 inches (1200 mm)]<Insert length>.
 - 5) Width: Not to exceed [8 inches (200 mm)]<Insert width>.
- c. Seals:
 - 1) Blades: Replaceable; extruded silicone as required by performance requirements. Seals are to be mechanically attached in extruded blade slots.
 - 2) Jambs: Stainless steel, compression type.
- d. Axles:
 - 1) Diameter: Minimum [0.375 inch (10 mm)][0.5 inch (13 mm)]<Insert diameter>.
 - 2) Material: Type 303 or 304 stainless steel.
 - 3) Mechanically attached to blades.
- e. Bearings:
 - 1) Material: [Molded nylon or]stainless steel sleeve, as required by operating conditions, mounted in frame.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
- f. Linkage:
 - 1) Hardware: Stainless steel.
 - 2) Material: Type 304 or 316 stainless steel.
 - 3) Mounting: Concealed in frame.
- g. Transitions with Sleeve:
 - 1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connections.
 - 2) Factory mount damper in a sleeve with a close transition to mate to field connection.
 - a) Sleeve length not less than [12 inches (300 mm)]<Insert length> for dampers without jackshafts and not less than [16 inches (450 mm)]<Insert length> for dampers with jackshafts.
 - b) Oversize damper and sleeve for duct connection size plus minimum [4 inches (100 mm)]<Insert dimension>.
 - 3) Fabricate sleeve and transitions of materials to match damper frame.

- 4) Match end connections (flange or sleeve) to field connections.

2.3 RECTANGULAR CONTROL DAMPERS WITH FLAT BLADES

A. General Requirements:

1. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
 - a. Include multisection damper assemblies with intermediate reinforcing where required between individual sections being joined together. Construct reinforcing of same material (aluminum, galvanized steel, stainless steel) as damper frame.
2. Factory install actuator(s) as integral part of damper assembly. Coordinate, with damper manufacturer, field requirements for actuators, such as type, fail-safe position, power supply, location, and mounting requirements.

B. Rectangular Control Dampers with Aluminum Flat Blades and Frames:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow United Industries; Mestek, Inc.]**
 - b. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow United Industries; Mestek, Inc.]**
 - b. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain rectangular control dampers, with aluminum flat blades and frames, from single manufacturer.
4. **[AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance and air leakage.]**
5. Performance:
 - a. Leakage:
 - 1) AMCA 511, Class 1, at **1 in. wg (250 Pa)** Differential Static Pressure: Leakage not to exceed **3.2 cfm/sq. ft. (16.2 L/s per sq. m)** against **1 in. wg (250 Pa)** differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: **[0.08 in. wg (20 Pa)]<Insert pressure drop>** at **[1500 fpm (7.6 m/s)]<Insert velocity>** across a **[24-by-24-inch (600-by-600-mm)]<Insert size>** damper when tested in accordance with AMCA 500D, figure **[5.3]<Insert figure no.>**.
 - c. Pressure Rating: **[2.0 in. wg (500 Pa)]<Insert pressure>**.
 - d. Temperature: **[Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)]<Insert temperature range>**.
 - e. Velocity: Up to **[2000 fpm (10 m/s)]<Insert velocity>**.

6. Construction:

a. Frame:

- 1) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, minimum **[0.08 inch (2 mm)][0.125 inch (3 mm)]** thick.
- 2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert size>** for attachment to duct flanges, plenum walls and equipment.
- 3) Width: Not less than **5 inches (125 mm)**.

b. Blades:

- 1) Configuration: Parallel or opposed blade configuration as required by application.
- 2) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, **0.125 inch (3 mm)** thick.
- 3) Shape: Single thickness.
- 4) Length: As required by pressure rating, not to exceed **[48 inches (1200 mm)]<Insert length>**.
- 5) Width: Not to exceed **6 inches (150 mm)**.

c. Seals:

- 1) Blades: Replaceable; extruded silicone or vinyl, as required by performance requirements. Mechanically attached in extruded blade slots.
- 2) Jambs: Stainless steel, compression type.

d. Axles:

- 1) Diameter: Minimum **0.5 inch (13 mm)**.
- 2) Material: Aluminum or plated steel.
- 3) Mechanically attached to blades.

e. Bearings:

- 1) Material: Celcon, polycarbonate or synthetic, mounted in frame.

f. Linkage:

- 1) Hardware: Plated or stainless steel.
- 2) Material: Aluminum or plated steel.
- 3) Mounting: Concealed in frame.

g. Additional Corrosion Protection for Corrosive Environments:

- 1) Provide anodized finish for aluminum surfaces in contact with airstream.

C. Rectangular Control Dampers with Galvanized-Steel Flat Blades and Frames:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain rectangular control dampers, with galvanized-steel flat blades and frames, from single manufacturer.
4. **[AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance and air leakage.]**
5. Performance:
 - a. Leakage:
 - 1) AMCA 511, Class II, at **1 in. wg (250 Pa)** Differential Static Pressure: Leakage not to exceed **5.4 cfm/sq. ft. (27.4 L/s per sq. m)** against **1 in. wg (250 Pa)** differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: **[0.1 in. wg (25 Pa)]<Insert pressure drop>** at **[1500 fpm (7.6 m/s)]<Insert velocity>** across a **[24-by-24-inch (600-by-600-mm)]<Insert size>** damper when tested in accordance with AMCA 500D, figure **[5.3]<Insert figure no.>**.
 - c. Pressure Rating: **[2.0 in. wg (500 Pa)][3.0 in. wg (750 Pa)][4.0 in. wg (1000 Pa)]<Insert pressure>**.
 - d. Temperature: **[Minus 20 to plus 185 deg F (Minus 29 to plus 85 deg C)]<Insert temperature range>**.
 - e. Velocity: Up to **[2000 fpm (10 m/s)]<Insert velocity>**.
6. Construction:
 - a. Frame:
 - 1) Material: ASTM A653/A653M galvanized steel, minimum **[0.06 inch (1.6 mm)]<Insert thickness>** thick.
 - 2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert size>** for attachment to duct flanges, plenum walls, and equipment.
 - 3) Width: Not less than **[5 inches (125 mm)]<Insert width>**.
 - b. Blades:
 - 1) Configuration: Parallel or opposed blade configuration as required by application.
 - 2) Material: ASTM A653/A653M galvanized steel, **[0.06 inch (1.6 mm)]<Insert thickness>** thick.
 - 3) Shape: Single thickness with bends for reinforcing.

- 4) Length: As required by pressure rating, not to exceed **[48 inches (1200 mm)]<Insert length>**.
 - 5) Width: Not to exceed **[8 inches (200 mm)]<Insert width>**.
 - c. Seals:
 - 1) Blades: Replaceable; extruded silicone, vinyl, **[or damper manufacturer-offered equivalent]**, as required by performance requirements. Seals are to be mechanically attached in extruded blade slots.
 - 2) Jambs: Stainless steel, compression type.
 - d. Axles:
 - 1) Diameter: Minimum **[0.375 inch (10 mm)] [0.5 inch (13 mm)]<Insert diameter>**.
 - 2) Material: **[Plated steel][or][stainless steel]**, **[specific to application indicated]**.
 - 3) Mechanically attached to blades.
 - e. Bearings:
 - 1) Material: Molded **[nylon][or][synthetic]**, or stainless steel sleeve, as required by operating conditions, mounted in frame.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
 - f. Linkage:
 - 1) Hardware: **[Plated][or][stainless]** steel.
 - 2) Material: **[Plated steel][or][stainless steel]**, **[specific to application indicated]**.
 - 3) Mounting: Concealed in frame.
 - g. Transitions with Sleeve:
 - 1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connections.
 - 2) Factory mount damper in a sleeve with a close transition to mate to field connection.
 - a) Sleeve length not less than **[12 inches (300 mm)]<Insert length>** for dampers without jackshafts and not less than **[16 inches (450 mm)]<Insert length>** for dampers with jackshafts.
 - b) Oversize damper and sleeve for duct connection size plus minimum **[4 inches (100 mm)]<Insert dimension>**.
 - 3) Fabricate sleeve and transitions of galvanized steel.
 - 4) Match end connections (flange or sleeve) to field connections.
 - h. Additional Corrosion Protection for Corrosive Environments:
 - 1) Paint surfaces exposed to airstream with an **[enamel][or][epoxy]<Insert finish>** finish. Prepare surfaces to be painted according to paint manufacturer's instructions.
- D. Rectangular Control Dampers with Stainless Steel Flat Blades and Frames:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. **[Arrow United Industries; Mestek, Inc.]**
 - b. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Arrow United Industries; Mestek, Inc.]**
 - b. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain rectangular control dampers, with stainless steel flat blades and frames, from single manufacturer.
4. **[AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance and air leakage.]**
5. Performance:
- a. Leakage:
 - 1) AMCA 511, Class II, at **1 in. wg (250 Pa)** Differential Static Pressure: Leakage not to exceed **5.4 cfm/sq. ft. (27.4 L/s per sq. m)** against **1 in. wg (250 Pa)** differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: **[0.1 in. wg (25 Pa)]<Insert pressure drop>** at **[1500 fpm (7.6 m/s)]<Insert velocity>** across a **[24-by-24-inch (600-by-600-mm)]<Insert size>** damper when tested in accordance with AMCA 500D, figure **[5.3]<Insert figure no.>**.
 - c. Pressure Rating: **[2.0 in. wg (500 Pa)][3.0 in. wg (750 Pa)][4.0 in. wg (1000 Pa)]<Insert pressure>**.
 - d. Temperature: **[Minus 20 to plus 185 deg F (Minus 29 to plus 85 deg C)]<Insert temperature range>**.
 - e. Velocity: Up to **[2000 fpm (10 m/s)]<Insert velocity>**.
6. Construction:
- a. Frame:
 - 1) Material: Type 304 stainless steel, minimum **[0.06 inch (1.6 mm)]<Insert thickness>** thick.
 - 2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert size>** for attachment to duct flanges, plenum walls, and equipment.
 - 3) Width: Not less than **[5 inches (125 mm)]<Insert width>**.
 - b. Blades:
 - 1) Configuration: Parallel or opposed blade configuration as required by application.
 - 2) Material: Type 304 stainless steel, **[0.06 inch (1.6 mm)]<Insert thickness>** thick.
 - 3) Shape: Single thickness with bends for reinforcing.
 - 4) Length: As required by pressure rating, not to exceed **[48 inches (1200 mm)]<Insert length>**.
 - 5) Width: Not to exceed **[8 inches (200 mm)]<Insert width>**.
 - c. Seals:

- 1) Blades: Replaceable; extruded silicone, vinyl, **[or damper manufacturer-offered equivalent]**, as required by performance requirements. Seals are to be mechanically attached in extruded blade slots.
 - 2) Jambs: Stainless steel, compression type.
- d. Axles:
- 1) Diameter: Minimum **[0.375 inch (10 mm)][0.5 inch (13 mm)]<Insert diameter>**.
 - 2) Material: Type 304 or 316 stainless steel.
 - 3) Mechanically attached to blades.
- e. Bearings:
- 1) Material: Molded **[nylon][or][synthetic]**, or stainless steel sleeve, as required by operating conditions, mounted in frame.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
- f. Linkage:
- 1) Hardware: Stainless steel.
 - 2) Material: Type 304 or 316 stainless steel.
 - 3) Mounting: Concealed in frame.
- g. Transitions with Sleeve:
- 1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connections.
 - 2) Factory mount damper in a sleeve with a close transition to mate to field connection.
 - a) Sleeve length not less than **[12 inches (300 mm)]<Insert length>** for dampers without jackshafts and not less than **[16 inches (450 mm)]<Insert length>** for dampers with jackshafts.
 - b) Oversize damper and sleeve for duct connection size plus minimum **[4 inches (100 mm)]<Insert dimension>**.
 - 3) Fabricate sleeve and transitions of Type 304 stainless steel.
 - 4) Match end connections (flange or sleeve) to field connections.

2.4 RECTANGULAR CONTROL DAMPERS WITH INSULATED BLADES

A. General Requirements:

1. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
 - a. Include multisection damper assemblies with intermediate reinforcing where required between individual sections being joined together. Construct reinforcing of same material (aluminum) as damper frame.
2. Factory install actuator(s) as integral part of damper assembly. Coordinate field requirements for actuators, such as type, fail-safe position, power supply, location, and mounting requirements with damper manufacturer.

B. Rectangular Control Dampers with Insulated Aluminum Airfoil Blades:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow United Industries; Mestek, Inc.]**
 - b. **[Greenheck Fan Corporation]**
 - c. **[Johnson Controls, Inc.]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow United Industries; Mestek, Inc.]**
 - b. **[Greenheck Fan Corporation]**
 - c. **[Johnson Controls, Inc.]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain rectangular control dampers, with insulated aluminum airfoil blades, from single manufacturer.
4. **[AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance, air leakage, and thermal performance.]**
5. Performance:
 - a. Leakage:
 - 1) AMCA 511, Class 1A, at **1 in. wg (250 Pa)** Differential Static Pressure: Leakage not to exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1 in. wg (250 Pa)** differential static pressure when tested in accordance with AMCA 500D.
 - 2) AMCA 511, Class 1, at **4 in. wg (1000 Pa)** Differential Static Pressure: Leakage not to exceed **8 cfm/sq. ft. (40.6 L/s per sq. m)** against **4 in. wg (1000 Pa)** differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: **[0.05 in. wg (12.5 Pa)]<Insert pressure drop>** at **[1500 fpm (7.6 m/s)]<Insert velocity>** across a **[24-by-24-inch (600-by-600-mm)]<Insert size>** damper when tested in accordance with AMCA 500D, figure **[5.3]<Insert figure no.>**.
 - c. Pressure Rating: Damper close-off pressure equal to **[fan shutoff pressure]<Insert requirement>**, not less than **[8.0 in. wg (2000 Pa)]<Insert pressure>**.
 - d. Temperature: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>**.
 - e. Thermal Performance:
 - 1) R-Value: **[2.2]<Insert value>** or higher.
 - 2) Thermal Efficiency Ratio (E): **[345]<Insert value>** or higher when tested in accordance with AMCA 500D.
 - f. Velocity: Up to **[4000 fpm (20 m/s)]<Insert velocity>**.
6. Construction:

- a. Frame:
 - 1) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, minimum [0.08 inch (2 mm)][0.125 inch (3 mm)]<Insert thickness> thick.
 - 2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert size> for attachment to duct flanges, plenum walls, and equipment.
 - 3) Width: Not less than [5 inches (125 mm)]<Insert width>.
- b. Blades:
 - 1) Configuration: Parallel or opposed blade configuration as required by application.
 - 2) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, [0.07 inch (1.8 mm)]<Insert thickness> thick.
 - 3) Shape: Airfoil.
 - 4) Length: As required by close-off pressure rating, not to exceed [48 inches (1200 mm)]<Insert length>.
 - 5) Width: Not to exceed [6 inches (150 mm)]<Insert width>.
 - 6) Insulation: Hollow airfoil blade internally insulated with expanded polyurethane foam for thermal performance indicated.
 - 7) Thermal Break: Complete thermal break with blades in full closed position.
- c. Seals:
 - 1) Blades: Replaceable; extruded EPDM, Santoprene or silicone, [or damper manufacturer-offered equivalent], as required by performance requirements. Seals are to be mechanically attached in extruded blade slots.
 - 2) Jams: Replaceable; polycarbonate, compression type [or mechanically attached extruded silicone].
- d. Axles:
 - 1) Diameter: Minimum [0.44 inch (11 mm)][0.5 inch (13 mm)]<Insert diameter>.
 - 2) Material: Aluminum or plated steel.
 - 3) Mechanically attached to blades.
- e. Bearings:
 - 1) Material: Molded inner and outer bearings of [acetal][Celcon][or][polycarbonate], as required by operating conditions.
 - 2) Mounting: Inner bearing fixed to axle, rotating within an outer bearing inserted in the frame, resulting in no metal-to-metal contact.
 - 3) Where blade axles are installed in vertical position, provide thrust bearings.
- f. Linkage:
 - 1) Hardware: [Plated][or][stainless] steel.
 - 2) Material: [Aluminum,][plated steel][or][stainless steel].
 - 3) Mounting: Concealed in frame.
- g. Transitions with Sleeve:
 - 1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connections.
 - 2) Factory mount damper in a sleeve with a close transition to mate to field connection.

- a) Sleeve length not less than **[12 inches (300 mm)]<Insert length>** for dampers without jackshafts and not less than **[16 inches (450 mm)]<Insert length>** for dampers with jackshafts.
 - b) Oversize damper and sleeve for duct connection size plus minimum **[4 inches (100 mm)]<Insert dimension>**.
 - 3) Fabricate sleeve and transitions of materials (aluminum, galvanized steel, or stainless steel) to match damper frame **[or adjoining duct]**.
 - 4) Match end connections (flange or sleeve) to field connections.
 - h. Additional Corrosion Protection for Corrosive Environments:
 - 1) Provide anodized finish, minimum of **0.0007 inch (0.018 mm)** thick, for aluminum surfaces in contact with airstream.
 - 2) Paint surfaces exposed to airstream with an **[enamel][or][epoxy]<Insert finish>** finish. Prepare surfaces to be painted according to paint manufacturer's instructions.
 - 3) Construct axles, damper linkage, and hardware of Type 316L stainless steel.
- C. Rectangular Control Dampers with Insulated Aluminum Airfoil Blades and Thermal Break Frames:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow United Industries; Mestek, Inc.]**
 - b. **[Greenheck Fan Corporation]**
 - c. **[Johnson Controls, Inc.]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow United Industries; Mestek, Inc.]**
 - b. **[Greenheck Fan Corporation]**
 - c. **[Johnson Controls, Inc.]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - f. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain rectangular control dampers, with insulated aluminum airfoil blades and thermal break, from single manufacturer.
 4. **[AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance, air leakage, and thermal performance.]**
 5. Performance:
 - a. Leakage:
 - 1) AMCA 511, Class 1A, at **1 in. wg (250 Pa)** Differential Static Pressure: Leakage not to exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1 in. wg (250 Pa)** differential static pressure when tested in accordance with AMCA 500D.
 - 2) AMCA 511, Class 1, at **4 in. wg (1000 Pa)** Differential Static Pressure: Leakage not to exceed **8 cfm/sq. ft. (40.6 L/s per sq. m)** against **4 in. wg (1000 Pa)** differential

static pressure when tested in accordance with AMCA 500D.

- b. Pressure Drop: [0.05 in. wg (12.5 Pa)]<Insert pressure drop> at [1500 fpm (7.6 m/s)]<Insert velocity> across a [24-by-24-inch (600-by-600-mm)]<Insert size> damper when tested in accordance with AMCA 500D, figure [5.3]<Insert figure no.>.
 - c. Pressure Rating: Damper close-off pressure equal to [fan shutoff pressure]<Insert requirement>, not less than [8.0 in. wg (2000 Pa)]<Insert pressure>.
 - d. Temperature: [Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>.
 - e. Thermal Performance:
 - 1) R-Value: [2.2]<Insert value> or higher.
 - 2) Thermal Efficiency Ratio (E): [345]<Insert value> or higher when tested in accordance with AMCA 500D.
 - f. Velocity: Up to [4000 fpm (20 m/s)]<Insert velocity>.
6. Construction:
- a. Frame:
 - 1) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, minimum [0.08 inch (2 mm)][0.125 inch (3 mm)]<Insert thickness> thick.
 - 2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert size> for attachment to duct flanges, plenum walls, and equipment.
 - 3) Thermal Break: Continuous extruded pocket at two locations, one on each side of closed damper blade, with polyurethane resin fill to achieve frame with no through metal.
 - 4) Width: Not less than [5 inches (125 mm)]<Insert width>.
 - b. Blades:
 - 1) Configuration: Parallel or opposed blade configuration as required by application.
 - 2) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, [0.07 inch (1.8 mm)]<Insert thickness> thick.
 - 3) Shape: Airfoil.
 - 4) Length: As required by close-off pressure rating, not to exceed [48 inches (1200 mm)]<Insert length>.
 - 5) Width: Not to exceed [6 inches (150 mm)]<Insert width>.
 - 6) Insulation: Hollow airfoil blade internally insulated with expanded polyurethane foam for thermal performance indicated.
 - 7) Thermal Break: Complete thermal break with blades in full closed position.
 - c. Seals:
 - 1) Blades: Replaceable; extruded EPDM, Santoprene or silicone, [or damper manufacturer-offered equivalent], as required by performance requirements. Seals are to be mechanically attached in extruded blade slots.
 - 2) Jambs: Replaceable; polycarbonate, compression type [or mechanically attached extruded silicone].
 - d. Axles:
 - 1) Diameter: Minimum [0.44 inch (11 mm)][0.5 inch (13 mm)]<Insert diameter>.

- 2) Material: Aluminum or plated steel.
 - 3) Mechanically attached to blades.
- e. Bearings:
- 1) Material: Molded inner and outer bearings of [acetal][Celcon][or][polycarbonate], as required by operating conditions.
 - 2) Mounting: Inner bearing fixed to axle, rotating within an outer bearing inserted in the frame, resulting in no metal-to-metal contact.
 - 3) Where blade axles are installed in vertical position, provide thrust bearings.
- f. Linkage:
- 1) Hardware: [Plated][or][stainless] steel.
 - 2) Material: [Aluminum,][plated steel][or][stainless steel].
 - 3) Mounting: Concealed in frame.
- g. Transitions with Sleeve:
- 1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connections.
 - 2) Factory mount damper in a sleeve with a close transition to mate to field connection.
 - a) Sleeve length not less than [12 inches (300 mm)]<Insert length> for dampers without jackshafts and not less than [16 inches (450 mm)]<Insert length> for dampers with jackshafts.
 - b) Oversize damper and sleeve for duct connection size plus minimum [4 inches (100 mm)]<Insert dimension>.
 - 3) Fabricate sleeve and transitions of materials (aluminum, galvanized steel, or stainless steel) to match damper frame[or adjoining duct].
 - 4) Match end connections (flange or sleeve) to field connections.
- h. Additional Corrosion Protection for Corrosive Environments:
- 1) Provide anodized finish, minimum of 0.0007 inch (0.018 mm) thick, for aluminum surfaces in contact with airstream.
 - 2) Paint surfaces exposed to airstream with an [enamel][or][epoxy]<Insert finish> finish. Prepare surfaces to be painted according to paint manufacturer's instructions.
 - 3) Construct axles, damper linkage, and hardware of Type 316L stainless steel.

2.5 RECTANGULAR CONTROL DAMPERS WITH INTEGRAL AIRFLOW MONITORING

A. General Requirements:

1. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
 - a. Include multisection damper assemblies with intermediate reinforcing where required between individual sections being joined together. Construct reinforcing of same material (aluminum) as damper frame.
2. Factory install actuator(s) as integral part of damper assembly. Coordinate field requirements for actuators, such as type, fail-safe position, power supply, location, and mounting requirements with damper manufacturer.

- B. Rectangular Control Dampers with Aluminum Airfoil Blades and Integral Airflow Monitoring:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ebtron, Inc]**
 - b. **[Greenheck Fan Corporation]**
 - c. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ebtron, Inc]**
 - b. **[Greenheck Fan Corporation]**
 - c. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain rectangular control dampers, with aluminum airfoil blades and integral airflow monitoring, from single manufacturer.
 4. **[AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance and air leakage.]**
 5. Performance:
 - a. Leakage:
 - 1) AMCA 511, Class 1A, at **1 in. wg (250 Pa)** Differential Static Pressure: Leakage not to exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1 in. wg (250 Pa)** differential static pressure when tested in accordance with AMCA 500D.
 - 2) AMCA 511, Class 1, at **4 in. wg (1000 Pa)** Differential Static Pressure: Leakage not to exceed **8 cfm/sq. ft. (40.6 L/s per sq. m)** against **4 in. wg (1000 Pa)** differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop (Damper and Airflow Measurement): **[0.15 in. wg (37.5 Pa)]<Insert pressure>** at **[1500 fpm (7.6 m/s)]<Insert velocity>** across a **[24-by-24-inch (600-by-600-mm)]<Insert size>** damper when tested in accordance with AMCA 500D, figure 5.3.
 - c. Pressure Rating: Damper close-off pressure equal to **[fan shutoff pressure]<Insert requirement>** with a maximum blade deflection of **[1/180]<Insert deflection>** of blade length.
 - d. Temperature: **[Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C)]<Insert temperature range>**.
 - e. Velocity (Damper Only): Up to **[4000 fpm (20 m/s)][5000 fpm (25 m/s)]<Insert velocity range>**.
 6. Construction:
 - a. Damper Frame:
 - 1) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, minimum **[0.125 inch (3 mm)]<Insert thickness>** thick.
 - 2) Arrangement: Hat-shaped channel with attachment to factory furnished sleeve.
 - 3) Width: Not less than **[5 inches (125 mm)]<Insert width>**.

- b. Damper Blades:
- 1) Configuration: Parallel or opposed blade configuration as required by application.
 - 2) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, [0.07 inch (1.8 mm)]<Insert thickness> thick.
 - 3) Shape: Hollow, airfoil.
 - 4) Length: As required by close-off pressure rating, not to exceed [48 inches (1200 mm)]<Insert length>.
 - 5) Width: Not to exceed [6 inches (150 mm)]<Insert width>.
- c. Damper Seals:
- 1) Blades: Replaceable; extruded Santoprene, silicone, [or damper manufacturer-offered equivalent], as required by performance requirements. Damper seals are to be mechanically attached in extruded blade slots.
 - 2) Jams: Replaceable; stainless steel, compression type [or mechanically attached extruded silicone].
- d. Axles:
- 1) Diameter: Minimum [0.375 inch (10 mm)][0.5 inch (13 mm)]<Insert diameter>.
 - 2) Material: [Aluminum,][plated steel][or][stainless steel], specific to application indicated].
 - 3) Mechanically attached to blades.
- e. Bearings:
- 1) Material: Molded [acetal][Celcon/polycarbonate][nylon][synthetic][or] stainless steel sleeve, as required by operating conditions, mounted in frame.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
- f. Linkage:
- 1) Hardware: [Plated][or][stainless] steel.
 - 2) Material: [Aluminum,][plated steel][or][stainless steel], specific to application indicated].
 - 3) Mounting: Concealed in frame.
- g. Sleeve:
- 1) General: Factory mount damper assembly and airflow measurement assembly in a common sleeve with a continuous-perimeter flanged face to mate to field connection. Coordinate field-mounting requirements for each application.
 - 2) Length: Not less than [15 inches (375 mm)][18 inches (450 mm)]<Insert dimension>.
 - 3) Material: [Aluminum][galvanized steel][stainless steel][or][aluminum, galvanized steel, or stainless steel to match adjoining duct].
 - 4) Thickness:
 - a) Sleeve Face Sizes through [24 inches (600 mm)]<Insert dimension>: Minimum [14 gauge (2 mm)][16 gauge (1.6 mm)]<Insert thickness>.
 - b) Sleeves with Larger Face Size: Minimum [12 gauge (2.7 mm)][14 gauge (2 mm)][16 gauge (1.6 mm)]<Insert thickness>.
- h. Additional Corrosion Protection for Corrosive Environments:

- 1) Provide anodized finish, minimum of **0.0007 inch (0.018 mm)** thick, for aluminum surfaces in contact with airstream.
 - 2) Paint surfaces exposed to airstream with an **[enamel][or][epoxy]<Insert finish>** finish. Prepare surfaces to be painted in accordance with paint manufacturer's instructions.
 - 3) Construct axles, damper linkage, and hardware of Type 316L stainless steel.
7. Pressure Airflow Measurement:
- a. Performance:
 - 1) Accuracy: Within **[3][5]<Insert number>** percent of the actual flow rate between the range of minimum to design airflow and velocity. For applications with a large variation in range between the minimum and design airflow, configure the damper sections and flow measurement assemblies as required to comply with the stated accuracy over entire modulating range.
 - 2) Velocity Range: **[300 to 2000 fpm (10 m/s)][300 to 5000 fpm (25 m/s)][Indicated on Drawings]<Insert velocity range>**.
 - 3) Provide temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
 - 4) Suitable for operation with untreated and unfiltered air.
 - b. Flow Straightener: Provide a straightening device as part of flow measurement assembly [, **if required**]to achieve specified accuracy with installed configuration indicated.
 - c. Flow Sensors: Hollow, ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles with anodized finish.
 - d. Placement: Locate upstream of damper.
 - e. Pressure Transducer: Housed in NEMA 250, **[Type 4]<Insert type>** painted enclosure.
 - f. Remote Output Signal: Zero- to 10 V dc **[or 4 to 20 mA]**scaled output signal proportional to flow for remote monitoring of actual airflow.
 - g. Tubing: Factory pipe transducer(s) to low- and high-pressure ports on flow sensors using manufacturer's standard tubing that is protected from damage during shipping and installation.
 - h. Factory Calibration: Factory calibrate each finished assembly before shipment in accordance with application-specific requirements.
8. Thermal Airflow Measurement:
- a. Certification:
 - 1) Listed and labeled in accordance with UL 873 or UL 60730.
 - 2) BTL certified in accordance with ASHRAE 135.
 - 3) 47 CFR, Ch. 1, Part 15, Subpart B, Class A device.
 - b. Performance:
 - 1) Airflow Accuracy: Within **[3][5]<Insert number>** percent of the actual flow rate between the range of minimum to design airflow. For applications with a large variation in range between the minimum and design airflow, configure the damper sections and flow measurement assemblies as required to comply with the stated accuracy over entire modulating range.
 - 2) Ambient Operating Humidity Range (Sensors and Transmitters): Zero to 99 percent, noncondensing.
 - 3) Temperature Accuracy: Within **0.2 deg F (0.1 deg C)** over entire range.
 - 4) Velocity Range: **[0 to 5000 fpm (25 m/s)][Indicated on Drawings]<Insert velocity**



9. Damper Actuator: Electric, modulating actuator with proportional control **[and position**

feedback]signals; complying with requirements in "Electric and Electronic Control-Damper Actuators" Article.

2.6 RECTANGULAR CONTROL DAMPERS WITH INTEGRAL AIRFLOW CONTROL

A. General Requirements:

1. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
 - a. Include multisection damper assemblies with intermediate reinforcing where required between individual sections being joined together. Construct reinforcing of same material (aluminum) as damper frame.
2. Factory install actuator(s) as integral part of damper assembly. Coordinate field requirements for actuators, such as type, fail-safe position, power supply, location, and mounting requirements with damper manufacturer.

B. Rectangular Control Dampers with Aluminum Airfoil Blades and Integral Airflow Control:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Greenheck Fan Corporation]**
 - b. **[Johnson Controls, Inc.]**
 - c. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Greenheck Fan Corporation]**
 - b. **[Johnson Controls, Inc.]**
 - c. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain rectangular control dampers, with aluminum airfoil blades and integral airflow control, from single manufacturer.
4. **[AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance and air leakage.]**
5. Performance:
 - a. Leakage:
 - 1) AMCA 511, Class 1A, at **1 in. wg (250 Pa)** Differential Static Pressure: Leakage not to exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1 in. wg (250 Pa)** differential static pressure when tested in accordance with AMCA 500D.
 - 2) AMCA 511, Class 1, at **4 in. wg (1000 Pa)** Differential Static Pressure: Leakage not to exceed **8 cfm/sq. ft. (40.6 L/s per sq. m)** against **4 in. wg (1000 Pa)** differential static pressure when tested in accordance with AMCA 500D.

- b. Pressure Drop (Damper and Flow Measurement): **[0.15 in. wg (37.5 Pa)]<Insert pressure>** at **[1500 fpm (7.6 m/s)]<Insert velocity>** across a **[24-by-24-inch (600-by-600-mm)]<Insert size>** damper when tested in accordance with AMCA 500D, figure 5.3.
 - c. Pressure Rating: Damper close-off pressure equal to **[fan shutoff pressure]<Insert requirement>** with a maximum blade deflection of **[1/180]<Insert deflection>** of blade length.
 - d. Temperature (Damper and Flow Measurement): **[Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C)]<Insert temperature range>**.
 - e. Velocity (Damper Only): Up to **[4000 fpm (20 m/s)][5000 fpm (25 m/s)]<Insert velocity range>**.
6. Construction:
 - a. Damper Frame:
 - 1) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, minimum **[0.125 inch (3 mm)]<Insert thickness>** thick.
 - 2) Arrangement: Hat-shaped channel with attachment to factory-furnished sleeve.
 - 3) Width: Not less than **[5 inches (125 mm)]<Insert width>**.
 - b. Damper Blades:
 - 1) Configuration: Parallel or opposed blade configuration as required by application.
 - 2) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, **[0.07 inch (1.8 mm)]<Insert thickness>** thick.
 - 3) Shape: Hollow, airfoil.
 - 4) Length: As required by close-off pressure rating, not to exceed **[48 inches (1200 mm)]<Insert length>**.
 - 5) Width: Not to exceed **[6 inches (150 mm)]<Insert width>**.
 - c. Damper Seals:
 - 1) Blades: Replaceable; extruded Santoprene, silicone, **[or damper manufacturer-offered equivalent]**, as required by performance requirements. Mechanically attached in extruded blade slots.
 - 2) Jambs: Replaceable; stainless steel, compression type **[or mechanically attached extruded silicone]**.
 - d. Axles:
 - 1) Diameter: Minimum **[0.375 inch (10 mm)][0.5 inch (13 mm)]<Insert diameter>**.
 - 2) Material: **[Plated steel][or][stainless steel]**, **specific to application indicated**.
 - 3) Mechanically attached to blades.
 - e. Bearings:
 - 1) Material: Molded **[acetal][Celcon/polycarbonate][nylon][synthetic][or]** stainless steel sleeve, as required by operating conditions, mounted in frame.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
 - f. Linkage:
 - 1) Hardware: **[Plated][or][stainless]** steel.
 - 2) Material: **[Aluminum,][plated steel][or][stainless steel]**, **specific to application indicated**.
 - 3) Mounting: Concealed in frame.

- g. Sleeve:
 - 1) General: Factory mount damper assembly and airflow measurement assembly in a common sleeve with a continuous-perimeter flanged face to mate to field connection. Coordinate field-mounting requirements for each application.
 - 2) Length: Not less than **[15 inches (375 mm)][18 inches (450 mm)]<Insert dimension>**.
 - 3) Material: **[Galvanized steel][galvanized steel or stainless steel to match adjoining duct][or][stainless steel]**.
 - 4) Thickness:
 - a) Sleeve Face Sizes through **[24 inches (600 mm)]<Insert dimension>**: Minimum **[14 gauge (2 mm)][16 gauge (1.6 mm)]<Insert thickness>**.
 - b) Sleeves with Larger Face Size: Minimum **[12 gauge (2.7 mm)][14 gauge (2 mm)][16 gauge (1.6 mm)]<Insert thickness>**.
- h. Additional Corrosion Protection for Corrosive Environments:
 - 1) Provide anodized finish, minimum of **0.0007 inch (0.018 mm)** thick, for aluminum surfaces in contact with airstream.
 - 2) Paint surfaces exposed to airstream with an **[enamel][or][epoxy]<Insert finish>** finish. Prepare surfaces to be painted according to paint manufacturer's instructions.
 - 3) Construct axles, damper linkage, and hardware of Type 316L stainless steel.
7. Pressure Airflow Measurement and Control:
 - a. Performance:
 - 1) Accuracy: Within **[3][5]<Insert number>** percent of the actual flow rate between the range of minimum to design airflow and velocity. For applications with a large variation in range between the minimum and design airflow, configure the damper sections and flow measurement assemblies as required to comply with the stated accuracy over entire modulating range.
 - 2) Velocity Range: **[150 to 2000 fpm (10 m/s)][Indicated on Drawings]<Insert velocity range>**.
 - 3) Provide temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
 - 4) Suitable for operation with untreated and unfiltered air.
 - b. Flow Straightener: Provide a straightening device as part of flow measurement assembly **[, if required]** to achieve specified accuracy with installed configuration indicated.
 - c. Flow Sensors: Hollow, ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles with anodized finish.
 - d. Placement: Locate upstream (inlet side) of damper.
 - e. Programmable Controller: Factory calibrated and programmed in nonvolatile memory for application-specific airflow set point(s) and range to control desired airflow. Include controller with the following:
 - 1) On-off power switch.
 - 2) Protection from transients and power surges.
 - 3) Circuitry to ensure reset after power disruption, transients, and brownouts.
 - f. Remote Control and Monitoring Interface:
 - 1) Airflow Measurement: 0 to 10 V dc or 4 to 20 mA scaled output signal proportional to

- airflow.
 - 2) Airflow Set Point: 0 to 10 V dc or 4 to 20 mA scaled input signal proportional to airflow.
 - 3) Carbon Dioxide Level: 0 to 10 V dc or 4 to 20 mA scaled input signal proportional to carbon dioxide.
 - 4) Damper Actuator Position Feedback: 0 to 10 V dc or 4 to 20 mA scaled output signal.
 - 5) Damper Position Override Command: 0 to 10 V dc or 4 to 20 mA scaled input signal.
 - 6) Set-Point Alarm: Binary signal.
 - 7) **<Insert remote interface requirement>.**
 - g. Remote Control and Monitoring Serial Interface: RS-485, BACnet-MS/TP.
 - h. Terminal Strip: Screw terminals for interface to field wiring.
 - i. Transformer: Rated for not less than **[100]<Insert value>** V A. Provide transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.
 - j. Tubing: Factory pipe transducer(s) to low- and high-pressure ports on flow sensors using manufacturer's standard tubing that is protected from damage during shipping and installation.
 - k. Control Enclosure: Factory mount controller, transducers, control transformer, terminal strip, and other control components and electronics within NEMA 250, **[Type 1 or 4 for indoor applications][Type 4 for outdoor applications]<Insert enclosure type>.**
 - l. Factory Calibration: Factory calibrate each finished assembly before shipment to the application-specific requirements.
8. Thermal Airflow Measurement and Control:
 - a. Certification:
 - 1) Listed and labeled in accordance with UL 873 or UL 60730.
 - 2) BTL certified in accordance with ASHRAE 135.
 - 3) 47 CFR, Ch. 1, Part 15, Subpart B, Class A device.
 - b. Performance:
 - 1) Airflow Accuracy: Within **[3][5]<Insert number>** percent of the actual flow rate between the range of minimum to design airflow. For applications with a large variation in range between the minimum and design airflow, configure the damper sections and flow measurement assemblies as required to comply with the stated accuracy over entire modulating range.
 - 2) Ambient Operating Humidity Range (Sensors and Transmitters): Zero to 99 percent, noncondensing.
 - 3) Temperature Accuracy: Within **0.2 deg F (0.1 deg C)** over entire range.
 - 4) Velocity Range: **[0 to 3000 fpm (15 m/s)][0 to 5000 fpm (25 m/s)][Indicated on Drawings]<Insert velocity range>.**
 - 5) Provide temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
 - 6) Suitable for operation in untreated and unfiltered air.
 - c. Flow Straightener: Provide a straightening device as part of flow measurement assembly **[, if required]**to achieve specified accuracy with installed configuration indicated.
 - d. Sensors:
 - 1) Number of sensors determined by manufacturer for application to comply with accuracy requirements indicated.
 - 2) Temperature of each sensor assembly velocity weighted and averaged by

transmitter before output if temperature sensor has an accuracy worse than **0.1 deg F (0.06 deg C)**.

- 3) Each sensor with two individually wired, hermetically sealed thermistors.
- 4) Mount thermistors in sensor using a marine-grade, waterproof material.
- 5) Protect thermistor leads, and do not expose to the environment.
- 6) Independently determine airflow rate and temperature at each sensor measurement point.
- 7) Furnish each sensor probe with an integral cable for connection to transmitter.
- 8) Sensor Probe Material: Anodized, extruded Alloy 6063 aluminum tube.
- 9) Probe Assembly-Mounting Brackets Material: **[Plated][or][stainless]** steel.
- 10) Connection Enclosure: NEMA 250, **[Type 1 or 4 for indoor applications][Type 4 for outdoor applications]<Insert enclosure type>**.

e. Transmitters:

- 1) Microprocessor based.
- 2) Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
- 3) Capable of field configuration and diagnostics using touch interface and digital display.
- 4) Password-protected programmable settings.
- 5) Field selectable between IP and SI units for airflow, temperature, and velocity.
- 6) Power supply, including the following:
 - a) On-off power switch.
 - b) Protection from transients and power surges.
 - c) Circuitry to ensure reset after power disruption, transients, and brownouts.
- 7) Enclosure: NEMA 250, **[Type 1 or 4 for indoor applications][Type 4 for outdoor applications]<Insert enclosure type>**.

f. Programmable Controller: Factory calibrated and programmed in nonvolatile memory for application-specific airflow set point(s) and range to control desired airflow. Include controller with the following:

- 1) On-off power switch.
- 2) Protection from transients and power surges.
- 3) Circuitry to ensure reset after power disruption, transients, and brownouts.
- 4) Digital display.
- 5) Capable of field configuration and diagnostics using touch interface and digital display.

g. Remote Control and Monitoring Interface:

- 1) Airflow Measurement: 0 to 10 V dc or 4 to 20 mA scaled output signal proportional to airflow.
- 2) Airflow Set Point: 0 to 10 V dc or 4 to 20 mA scaled input signal proportional to airflow.
- 3) Carbon Dioxide Level: 0 to 10 V dc or 4 to 20 mA scaled input signal proportional to carbon dioxide.
- 4) Damper Actuator Position Feedback: 0 to 10 V dc or 4 to 20 mA scaled output signal.
- 5) Damper Position Override Command: 0 to 10 V dc or 4 to 20 mA scaled input signal.
- 6) Set-Point Alarm: Binary signal.

- 7) Temperature Measurement: 0 to 10 V dc or 4 to 20 mA scaled output signal proportional to air temperature.
- 8) **<Insert remote interface requirement>.**
- h. Remote Control and Monitoring Serial Interface: RS-485, BACnet-MS/TP; Ethernet, BACnet Ethernet, or BACnet-IP.
- i. Terminal Strip: Screw terminals for interface to field wiring.
- j. Transformer: Rated for not less than **[100]<Insert value>** V A. Provide transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.
- k. Control Enclosure: Factory mount controller, control transformer, and terminal strip within NEMA 250, **[Type 1 or 4 for indoor applications][Type 4 for outdoor applications]<Insert enclosure type>.**
- l. Factory Calibration: Factory calibrate each airflow station at a minimum of **[16]<Insert value>** airflow rates and **[three]<Insert value>** temperatures to standards that are traceable to NIST.
9. Damper Actuator: Electric, modulating actuator with proportional control **[and position feedback]**signals; complying with requirements in "Electric and Electronic Control-Damper Actuators" Article.

2.7 RECTANGULAR INDUSTRIAL-DUTY CONTROL DAMPERS

A. General Requirements:

1. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
 - a. Include intermediate reinforcing required between individual sections being joined together of same material (galvanized steel, stainless steel) as damper frame.
2. Factory install actuator(s) as integral part of damper assembly. Coordinate field requirements for actuators, such as type, fail-safe position, power supply, location, and mounting requirements with damper manufacturer.

B. Rectangular Industrial-Duty Control Dampers with Galvanized-Steel Airfoil Blades and Frames:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**

- d. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain rectangular industrial-duty control dampers, with galvanized-steel airfoil blades and frames, from single manufacturer.
 4. Performance:
 - a. Leakage: Not to exceed [3 cfm/sq. ft. (15.2 L/s per sq. m)][4 cfm/sq. ft. (20.3 L/s per sq. m)]<Insert value> against [1 in. wg (250 Pa)]<Insert value> differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: [0.1 in. wg (25 Pa)]<Insert pressure drop> at [1500 fpm (7.6 m/s)]<Insert velocity> across a [24-by-24-inch (600-by-600-mm)]<Insert size> damper when tested in accordance with AMCA 500D, figure [5.3]<Insert figure no.>.
 - c. Pressure Rating: Damper close-off pressure equal to [fan shutoff pressure]<Insert requirement> with a maximum blade deflection of [1/240]<Insert deflection> of blade length, but not less than [10 in. wg (2500 Pa)]<Insert pressure>.
 - d. Temperature: [Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)][Minus 40 to plus 400 deg F (Minus 40 to plus 204 deg C)]<Insert temperature range>.
 - e. Velocity: Up to [4000 fpm (20 m/s)][5000 fpm (25 m/s)][6000 fpm (30 m/s)]<Insert velocity>.
 5. Construction:
 - a. Frame:
 - 1) Material: Galvanized steel.
 - 2) Shape: C-shaped channel.
 - 3) Mating Face Size: Minimum [2 inches (50 mm)]<Insert size>.
 - 4) Thickness: Minimum [14 gauge (2 mm)]<Insert thickness> thick.
 - 5) Width: Not less than [8 inches (250 mm)][open blade width plus 2 inches (50 mm)]<Insert dimension>.
 - b. Blades:
 - 1) Configuration: Parallel or opposed blade as required by application.
 - 2) Material: Galvanized steel.
 - 3) Thickness: Minimum [14 gauge (2 mm)][16 gauge (1.6 mm)]<Insert thickness> thick.
 - 4) Shape: Hollow, airfoil.
 - 5) Length: Not to exceed [36 inches (900 mm)][48 inches (1200 mm)][60 inches (1500 mm)]<Insert dimension>.
 - 6) Width: Not to exceed [6 inches (150 mm)][8 inches (200 mm)]<Insert dimension>.
 - c. Seals:
 - 1) Blades: Replaceable, mechanically attached [silicone][or][stainless steel]<Insert material>.
 - 2) Jambs: Stainless steel, [double]compression type.
 - d. Axles:
 - 1) Attachment: Mechanically attached to blades.
 - 2) Diameter: Minimum 0.75 inch (19 mm).
 - 3) Material: [Plated][or][stainless].

- 4) Length: **[Continuous across entire length of blade]<Insert length>**.
 - e. Bearings:
 - 1) Material: Stainless steel.
 - 2) Mounting: **[Bolted to frame][Pressed into frame][Bolted or pressed in frame][Outboard bearings bolted to frame with shaft seals][Mounting requirements as indicated by application]<Insert mounting requirements>**.
 - 3) Where blade axles are installed in vertical position, provide thrust bearings.
 - f. Linkage:
 - 1) Arrangement: **[Blade-to-blade linkage concealed in frame][Blade-to-blade face linkage exposed to airstream]<Insert requirement>**.
 - 2) Material: **[Plated][or][stainless]**.
 - 3) Hardware: Stainless steel.
 - g. Additional Corrosion Protection for Corrosive Environments:
 - 1) **[Where indicated, paint][Paint]** surfaces exposed to airstream with an **[enamel][or][epoxy]<Insert finish>** finish. Prepare surfaces to be painted according to paint manufacturer's instructions.
- C. Rectangular Industrial-Duty Control Dampers with Stainless Steel Airfoil Blades and Frames:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain rectangular industrial-duty control dampers, with stainless steel airfoil blades and frames, from single manufacturer.
 4. Performance:
 - a. Leakage: Not to exceed **[3 cfm/sq. ft. (15.2 L/s per sq. m)][4 cfm/sq. ft. (20.3 L/s per sq. m)]<Insert value>** against **[1 in. wg (250 Pa)]<Insert value>** differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: **[0.1 in. wg (25 Pa)]<Insert pressure drop>** at **[1500 fpm (7.6 m/s)]<Insert velocity>** across a **[24-by-24-inch (600-by-600-mm)]<Insert size>** damper when tested in accordance with AMCA 500D, figure **[5.3]<Insert figure no.>**.

- c. Pressure Rating: Damper close-off pressure equal to [fan shutoff pressure]<Insert requirement> with a maximum blade deflection of [1/240]<Insert deflection> of blade length, but not less than [10 in. wg (2500 Pa)]<Insert pressure>.
 - d. Temperature: [Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)][Minus 40 to plus 400 deg F (Minus 40 to plus 204 deg C)]<Insert temperature range>.
 - e. Velocity: Up to [4000 fpm (20 m/s)][5000 fpm (25 m/s)][6000 fpm (30 m/s)]<Insert velocity>.
5. Construction:
- a. Frame:
 - 1) Material: Stainless steel, [Type 304][or][Type 316][Type 304 or 316 as indicated by application]<Insert type>.
 - 2) Shape: C-shaped channel.
 - 3) Mating Face Size: Minimum [2 inches (50 mm)]<Insert size>.
 - 4) Thickness: Minimum [14 gauge (2 mm)]<Insert thickness> thick.
 - 5) Width: Not less than [8 inches (250 mm)][open blade width plus 2 inches (50 mm)]<Insert dimension>.
 - b. Blades:
 - 1) Configuration: Parallel or opposed blade as required by application.
 - 2) Material: Stainless steel, [Type 304][or][Type 316][Type 304 or 316 as indicated by application]<Insert type>.
 - 3) Thickness: Minimum [14 gauge (2 mm)][16 gauge (1.6 mm)]<Insert thickness> thick.
 - 4) Shape: Hollow, airfoil.
 - 5) Length: Not to exceed [36 inches (900 mm)][48 inches (1200 mm)][60 inches (1500 mm)]<Insert dimension>.
 - 6) Width: Not to exceed [6 inches (150 mm)][8 inches (200 mm)]<Insert dimension>.
 - c. Seals:
 - 1) Blades: Replaceable, mechanically attached [silicone][or][stainless steel]<Insert material>.
 - 2) Jams: Type 316 stainless steel, [double]compression type.
 - d. Axles:
 - 1) Attachment: Mechanically attached to blades.
 - 2) Diameter: Minimum 0.75 inch (19 mm).
 - 3) Material: Stainless steel, [Type 304][or][Type 316][Type 304 or 316 as indicated by application]<Insert type>.
 - 4) Length: [Continuous across entire length of blade]<Insert length>.
 - e. Bearings:
 - 1) Material: Stainless steel.
 - 2) Mounting: [Bolted to frame][Pressed into frame][Bolted or pressed in frame][Outboard bearings bolted to frame with shaft seals][Mounting requirements as indicated by application]<Insert mounting requirements>.
 - 3) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

- 1) Arrangement: **[Blade-to-blade linkage concealed in frame][Blade-to-blade face linkage exposed to airstream]<Insert requirement>**.
- 2) Material: Stainless steel, **[Type 304][or][Type 316][Type 304 or 316 as indicated by application]<Insert type>**.
- 3) Hardware: Stainless steel, **[Type 304][or][Type 316][Type 304 or 316 as indicated by application]<Insert type>**.

2.8 ROUND CONTROL DAMPERS

A. General Requirements:

1. Factory install actuator as integral part of damper assembly. Coordinate field requirements for actuators, such as type, fail-safe position, power supply, location, and mounting requirements with damper manufacturer.

B. Round, Galvanized-Steel Control Dampers with Sleeve End Connections:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain round, galvanized-steel control dampers with sleeve end connections from single manufacturer.
4. Performance:
 - a. Leakage: Not to exceed **[0.15 cfm/in. (0.0028 L/s per mm)]<Insert leakage>** of perimeter blade at **[4 in. wg (1000 Pa)]<Insert pressure>** differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: **0.05 in. wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **12-inch (300-mm)** damper when tested in accordance with AMCA 500D, figure 5.3.
 - c. Pressure Rating: **[4 in. wg (1000 Pa)][6 in. wg (1500 Pa)][8 in. wg (2000 Pa) for sizes through 12 inches (300 mm), 6 in. wg (1500 Pa) for larger sizes]<Insert pressure>**.
 - d. Temperature: Up to **[180 deg F (82 deg C)][200 deg F (93 deg C)]<Insert temperature>**.
 - e. Velocity: Up to **[3000 fpm (15 m/s)][4000 fpm (20 m/s)]<Insert velocity>**.

5. Size Range: **[4 to 24 inches (100 to 600 mm)]<Insert size range>**.
6. Construction:
 - a. Frame:
 - 1) End Connection: Sleeve-type connection for mating to adjacent ductwork.
 - 2) Length: Minimum **6 inches (150 mm)**.
 - 3) Material: Galvanized steel, minimum **20 gauge (1.0 mm)** thick.
 - 4) Stiffeners: Outward-turned beads positioned approximately **1-1/2 inches (38 mm)** inboard of each end.
 - 5) Standoff: Provide **2-inch- (50-mm-)** high, sheet metal standoff for mounting actuator to axle while accommodating field-installed duct insulation.
 - b. Blade: Double-thickness circular flat blades sandwiched together and constructed of galvanized steel.
 - c. Blade Seal: EPDM, neoprene or silicone seal fully encompassing blade edge.
 - d. Axle: **0.5-inch- (13-mm-)** diameter plated steel, mechanically attached to blade.
 - e. Bearings: Bronze or stainless steel sleeve pressed into frame.

C. Round, Stainless Steel Control Dampers with Sleeve End Connections:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain round, stainless steel control dampers with sleeve end connections from single manufacturer.
4. Performance:
 - a. Leakage: Not to exceed **[0.15 cfm/in. (0.0028 L/s per mm)]<Insert leakage>** of perimeter blade at **[4 in. wg (1000 Pa)]<Insert pressure>** differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: **0.05 in. wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **12-inch (300-mm)** damper when tested in accordance with AMCA 500D, figure 5.3.
 - c. Pressure Rating: **[4 in. wg (1000 Pa)][6 in. wg (1500 Pa)][8 in. wg (2000 Pa) for sizes through 12 inches (300 mm), 6 in. wg (1500 Pa) for larger sizes]<Insert pressure>**.

- d. Temperature: Up to [180 deg F (82 deg C)][200 deg F (93 deg C)]<Insert temperature>.
 - e. Velocity: Up to [3000 fpm (15 m/s)][4000 fpm (20 m/s)]<Insert velocity>.
5. Size Range: [4 to 24 inches (100 to 600 mm)]<Insert size range>.
 6. Construction:
 - a. Frame:
 - 1) End Connection: Sleeve-type connection for mating to adjacent ductwork.
 - 2) Length: Minimum **6 inches (150 mm)**.
 - 3) Material: Type 304 stainless steel, minimum **20 gauge (1.0 mm)** thick.
 - 4) Stiffeners: Outward-turned beads positioned approximately **1-1/2 inches (38 mm)** inboard of each end.
 - 5) Standoff: Provide **2-inch- (50-mm-)** high, sheet metal standoff for mounting actuator to axle while accommodating field-installed duct insulation.
 - b. Blade: Double-thickness circular flat blades sandwiched together and constructed of Type 304 stainless steel.
 - c. Blade Seal: EPDM, neoprene or silicone seal fully encompassing blade edge.
 - d. Axle: **0.5-inch- (13-mm-)** diameter, Type 304 or 316 stainless steel, mechanically attached to blade.
 - e. Bearings: Bronze or stainless steel sleeve pressed into frame.
- D. Round, Galvanized-Steel Control Dampers with Flanged End Connections:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Warming and Ventilating (AWV); Mestek, Inc.]
 - b. [Arrow United Industries; Mestek, Inc.]
 - c. [Greenheck Fan Corporation]
 - d. [Johnson Controls, Inc.]
 - e. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Warming and Ventilating (AWV); Mestek, Inc.]
 - b. [Arrow United Industries; Mestek, Inc.]
 - c. [Greenheck Fan Corporation]
 - d. [Johnson Controls, Inc.]
 - e. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - f. <Insert manufacturer's name>
 3. Source Limitations: Obtain round, galvanized-steel control dampers with flanged end connections from single manufacturer.
 4. Performance:
 - a. Leakage: Not to exceed [0.15 cfm/in. (0.0028 L/s per mm)]<Insert leakage> of perimeter blade at [4 in. wg (1000 Pa)]<Insert pressure> differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: **0.05 in. wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **12-inch (300-mm)**

- damper when tested in accordance with AMCA 500D, figure 5.3.
- c. Pressure Rating: [4 in. wg (1000 Pa)][6 in. wg (1500 Pa)][8 in. wg (2000 Pa) for sizes through 12 inches (300 mm), 6 in. wg (1500 Pa) for larger sizes]<Insert pressure>.
 - d. Temperature: Up to [250 deg F (121 deg C)]<Insert temperature>.
 - e. Velocity: Up to [2500 fpm (13 m/s)][3000 fpm (15 m/s)][4000 fpm (20 m/s)]<Insert velocity>.
5. Size Range: [4 to 48 inches (100 to 1200 mm)]<Insert size range>.
6. Construction:
- a. Frame:
 - 1) Material: Galvanized steel, thickness as follows:
 - a) Sizes through **18 Inches (450 mm)** in Diameter: Minimum **16 gauge (1.6 mm)** thick.
 - b) Larger Sizes: Minimum **12 gauge (2.8 mm)** thick.
 - 2) Flanges:
 - a) Outward-turned flanges with bolt holes on each end of frame for mating to adjacent ductwork.
 - b) Face: Not less than **1-1/2 inches (38 mm)**.
 - c) Thickness: Minimum **12 gauge (2.8 mm)** thick.
 - 3) Length (Flange Face to Face): Not less than **8 inches (200 mm)**.
 - 4) Standoff: Provide **3-inch- (75-mm-)** high, standoff for mounting actuator to axle while accommodating field-installed duct insulation.
 - b. Blade: Reinforced double-thickness circular flat blades sandwiched together or reinforced single-thickness circular flat blades; constructed of galvanized steel.
 - 1) Double-Thickness Blades (Each Side):
 - a) Sizes through **18 Inches (450 mm)**: Minimum **18 gauge (1.3 mm)** thick.
 - b) Larger Sizes: Minimum **16 gauge (1.6 mm)** thick.
 - 2) Single-Thickness Blades:
 - a) Sizes through **36 Inches (900 mm)**: Minimum **14 gauge (2 mm)** thick.
 - b) Larger Sizes: Minimum **12 gauge (2.8 mm)** thick.
 - c. Blade Stop: Located in airstream; galvanized steel, full-circumference bar[or pin].
 - d. Blade Seal: EPDM, neoprene or silicone, mechanically attached to blade and fully encompassing blade edge. For double-thickness blade designs, sandwich seal between blades.
 - e. Axle: Continuous, plated steel, mechanically attached to blade and angle reinforced as required.
 - 1) Blade Diameter through **24 Inches (600 mm)**: Minimum **1/2-inch (13-mm)** axle diameter.
 - 2) Larger Sizes: Minimum **3/4-inch (19-mm)** axle diameter.
 - f. Bearings: [**Bronze or**]stainless steel sleeve pressed into frame.

E. Round, Stainless Steel Control Dampers with Flanged End Connections:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain round, stainless steel control dampers with flanged end connections from single manufacturer.
4. Performance:
 - a. Leakage: Not to exceed **[0.15 cfm/in. (0.0028 L/s per mm)]<Insert leakage>** of perimeter blade at **[4 in. wg (1000 Pa)]<Insert pressure>** differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: **0.05 in. wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **12-inch (300-mm)** damper when tested in accordance with AMCA 500D, figure 5.3.
 - c. Pressure Rating: **[4 in. wg (1000 Pa)][6 in. wg (1500 Pa)][8 in. wg (2000 Pa) for sizes through 12 inches (300 mm), 6 in. wg (1500 Pa) for larger sizes]<Insert pressure>**.
 - d. Temperature: Up to **[250 deg F (121 deg C)]<Insert temperature>**.
 - e. Velocity: Up to **[2500 fpm (13 m/s)][3000 fpm (15 m/s)][4000 fpm (20 m/s)]<Insert velocity>**.
5. Size Range: **[4 to 48 inches (100 to 1200 mm)]<Insert size range>**.
6. Construction:
 - a. Frame:
 - 1) Material: Type 304 stainless steel, thickness as follows:
 - a) Sizes through **18 Inches (450 mm)** in Diameter: Minimum **16 gauge (1.6 mm)** thick.
 - b) Larger Sizes: Minimum **12 gauge (2.8 mm)** thick.
 - 2) Flanges:
 - a) Outward-turned flanges with bolt holes on each end of frame for mating to adjacent ductwork.
 - b) Face: Not less than **1-1/2 inches (38 mm)**.
 - c) Thickness: Minimum **12 gauge (2.8 mm)** thick.

- 3) Length (Flange Face to Face): Not less than **8 inches (200 mm)**.
- 4) Standoff: Provide **3-inch- (75-mm-)** high, standoff for mounting actuator to axle while accommodating field-installed duct insulation.
- b. Blade: Reinforced double-thickness circular flat blades sandwiched together or reinforced single-thickness circular flat blades; constructed of Type 304 stainless steel.
 - 1) Double-Thickness Blades (Each Side):
 - a) Sizes through **18 Inches (450 mm)**: Minimum **18 gauge (1.3 mm)** thick.
 - b) Larger Sizes: Minimum **16 gauge (1.6 mm)** thick.
 - 2) Single-Thickness Blades:
 - a) Sizes through **36 Inches (900 mm)**: Minimum **14 gauge (2 mm)** thick.
 - b) Larger Sizes: Minimum **12 gauge (2.8 mm)** thick.
- c. Blade Stop: Located in airstream; Type 304 stainless steel, full-circumference bar[**or pin**].
- d. Blade Seal: EPDM, neoprene or silicone, mechanically attached to blade and fully encompassing blade edge. For double-thickness blade designs, sandwich seal between blades.
- e. Axle: Continuous, Type 304 stainless steel, mechanically attached to blade and angle reinforced as required.
 - 1) Blade diameter through **24 Inches (600 mm)**: Minimum **1/2-inch (13-mm)** axle diameter.
 - 2) Larger Sizes: Minimum **3/4-inch (19-mm)** axle diameter.
- f. Bearings: Stainless steel sleeve pressed into frame.

2.9 ROUND INDUSTRIAL-DUTY CONTROL DAMPERS

A. General Requirements:

1. Factory install actuator as integral part of damper assembly. Coordinate field requirements for actuators, such as type, fail-safe position, power supply, location, and mounting requirements with damper manufacturer.

B. Round, Carbon Steel, Industrial-Duty Control Dampers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain round, carbon steel, industrial-duty control dampers from single manufacturer.
 4. Performance:
 - a. Leakage: Not to exceed **[0.15 cfm/in. (0.0028 L/s per mm)]<Insert leakage>** of perimeter blade at **[4 in. wg (1000 Pa)]<Insert pressure>** differential static pressure when tested in accordance with AMCA 500D.
 - b. Pressure Drop: **0.05 in. wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **12-inch (300-mm)** damper when tested in accordance with AMCA 500D, figure 5.3.
 - c. Pressure Rating: Minimum **[13 in. wg (3250 Pa)]<Insert pressure>**.
 - d. Temperature: Up to **[250 deg F (121 deg C)][400 deg F (204 deg C)]<Insert temperature>**.
 - e. Velocity: Up to **[5000 fpm (25 m/s)][6000 fpm (30 m/s)]<Insert velocity>**.
 5. Size Range: **[4 to 72 inches (100 to 1800 mm)]<Insert size range>**.
 6. Construction:
 - a. Frame:
 - 1) Material: Carbon steel.
 - a) Sizes through **24 Inches (600 mm)** in Diameter: Minimum **10 gauge (4 mm)** thick.
 - b) Sizes **26 through 48 Inches (650 through 1200 mm)** in Diameter: Minimum **1/4 inch (6 mm)** thick.
 - c) Larger Sizes: Minimum **5/16 inch (8 mm)** thick.
 - 2) Flanges:
 - a) Outward-turned flanges with bolt holes on each end of frame for mating to adjacent ductwork.
 - b) Face: Not less than **1-1/4 inches (31 mm)** for damper sizes through **12 inches (300 mm)** in diameter, **1-1/2 inches (38 mm)** for damper sizes **14 through 24 inches (350 through 600 mm)** in diameter, and **2 inches (50 mm)** for larger sizes.
 - 3) Length (Flange Face to Face):
 - a) Sizes through **8 Inches (200 mm)** in Diameter: Not less than **6 inches (150 mm)**.
 - b) Larger Sizes: Not less than **9 inches (225 mm)**.
 - 4) Standoff: Provide **3-inch (75-mm)** standoff for mounting actuator to axle while accommodating field-installed duct insulation.
 - b. Blade: Reinforced circular flat blade constructed of carbon steel.
 - 1) Sizes through **24 Inches (600 mm)**: Minimum **0.15 inch (4 mm)** thick.

- 2) Sizes **26 through 48 Inches (650 through 1200 mm)**: Minimum **0.19 inch (5 mm)** thick.
- 3) Larger Sizes: Minimum **1/4 inch (6 mm)** thick.
- c. Blade Stop: Full-circumference carbon steel bar, minimum **1/2 by 1/4 inch (13 by 6 mm)**.
- d. Blade Seal: EPDM, neoprene or silicone, mechanically attached to blade and fully encompassing blade edge.
- e. Axle: Continuous plated-steel axle mechanically attached to blade and angle reinforced as required.
 - 1) Blade Diameter through **32 Inches (800 mm)**: Minimum **3/4 inch (19 mm)** in diameter axle.
 - 2) Blade Diameter **33 through 44 Inches (825 through 1100 mm)**: Minimum **1-inch (19-mm)** axle diameter.
 - 3) Blade Diameter **45 through 52 Inches (1125 through 1300 mm)**: Minimum **1-1/2-inch (38-mm)** axle diameter.
 - 4) Larger Sizes: Minimum **2-inch (50-mm)** axle diameter.
- f. Axle Shaft Seals: **[Viton O-rings][or][double gland stuffing boxes]** where indicated for application.
- g. Bearings: **[Grease-lubricated ball bearings bolted to frame][Bolted grease-lubricated ball bearings located on outboard of frame with axle shaft seals]**.
7. Finish: Prime and paint carbon steel surfaces with a corrosion-resistant finish as recommended by manufacturer and suitable for airstream encountered at temperature range indicated. Prepare surfaces to be finished according to paint manufacturer's requirements.

C. Round, Stainless Steel, Industrial-Duty Control Dampers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Greenheck Fan Corporation]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain round, stainless steel, industrial-duty control dampers from single manufacturer.
4. Performance:
 - a. Leakage: Not to exceed **[0.15 cfm/in. (0.0028 L/s per mm)]<Insert leakage>** of perimeter

- blade at **[4 in. wg (1000 Pa)]<Insert pressure>** differential static pressure when tested in accordance with AMCA 500D.
- b. Pressure Drop: **0.05 in. wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **12-inch (300-mm)** damper when tested in accordance with AMCA 500D, figure 5.3.
 - c. Pressure Rating: Minimum **[13 in. wg (3250 Pa)]<Insert pressure>**.
 - d. Temperature: Up to **[250 deg F (121 deg C)][400 deg F (204 deg C)]<Insert temperature>**.
 - e. Velocity: Up to **[5000 fpm (25 m/s)][6000 fpm (30 m/s)]<Insert velocity>**.
5. Size Range: **[4 to 72 inches (100 to 1800 mm)]<Insert size range>**.
 6. Construction:
 - a. Frame:
 - 1) Material: Stainless steel, **[Type 304][or][Type 316][Type 304 or 316 as indicated by application]<Insert type>**.
 - a) Sizes through **24 Inches (600 mm)** in Diameter: Minimum **10 gauge (4 mm)** thick.
 - b) Sizes **26 through 48 Inches (650 through 1200 mm)** in Diameter: Minimum **1/4 inch (6 mm)** thick.
 - c) Larger Sizes: Minimum **5/16 inch (8 mm)** thick.
 - 2) Flanges:
 - a) Outward-turned flanges with bolt holes on each end of frame for mating to adjacent ductwork.
 - b) Face: Not less than **1-1/4 inches (31 mm)** for damper sizes through **12 inches (300 mm)** in diameter, **1-1/2 inches (38 mm)** for damper sizes **14 through 24 inches (350 through 600 mm)** in diameter, and **2 inches (50 mm)** for larger sizes.
 - 3) Length (Flange Face to Face):
 - a) Sizes through **8 Inches (200 mm)** in Diameter: Not less than **6 inches (150 mm)**.
 - b) Larger Sizes: Not less than **9 inches (225 mm)**.
 - 4) Standoff: Provide **3-inch (75-mm)** standoff for mounting actuator to axle while accommodating field-installed duct insulation.
 - b. Blade: Reinforced circular flat blade constructed of stainless steel, **[Type 304][or][Type 316][Type 304 or 316 as indicated by application]<Insert type>**.
 - 1) Sizes through **24 Inches (600 mm)**: Minimum **0.15 inch (4 mm)** thick.
 - 2) Sizes **26 through 48 Inches (650 through 1200 mm)**: Minimum **0.19 inch (5 mm)** thick.
 - 3) Larger Sizes: Minimum **1/4 inch (6 mm)** thick.
 - c. Blade Stop: Full-circumference bar, minimum **1/2 by 1/4 inch (13 by 6 mm)** stainless steel, **[Type 304][or][Type 316][Type 304 or 316 as indicated by application]<Insert type>**.
 - d. Blade Seal: EPDM, neoprene or silicone, mechanically attached to blade and fully encompassing blade edge.
 - e. Axle: Continuous axle mechanically attached to blade and angle reinforced as required. Axle constructed of stainless steel, **[Type 304][or][Type 316][Type 304 or 316 as**

indicated by application]<Insert type>.

- 1) Blade Diameter through 32 Inches (800 mm): Minimum 3/4-inch (19-mm) axle diameter.
 - 2) Blade Diameter 33 through 44 Inches (825 through 1100 mm): Minimum 1-inch (19-mm) axle diameter.
 - 3) Blade Diameter 45 through 52 Inches (1125 through 1300 mm): Minimum 1-1/2-inch (38-mm) axle diameter.
 - 4) Larger Sizes: Minimum 2-inch (50-mm) axle diameter.
- f. Axle Shaft Seals: [Viton O-rings][or][double gland stuffing boxes] where indicated for application.
- g. Bearings: [Grease-lubricated ball bearings bolted to frame][Bolted grease-lubricated ball bearings located on outboard of frame with axle shaft seals].
7. Finish: [Mill]<Insert finish>.

2.10 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

- A. Select actuators to operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.
- B. Select actuators with sufficient power and torque to close off against the maximum system pressures encountered. Actuators are to be sized to close off against the fan shutoff pressure as a minimum requirement.
- C. The total damper area operated by an actuator is not to exceed 80 percent of manufacturer's maximum area rating.
- D. Provide one actuator for each damper assembly where possible. Operate multiple actuators required to drive a single damper assembly in unison.
- E. Avoid the use of excessively oversized actuators, which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
- F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
- G. Provide mounting hardware and linkages for connecting actuator to damper.
- H. Select actuators to fail-safe in desired position in the event of a power [and signal]failure.
- I. Actuator Fail-Safe Positions: [See Drawings.][As indicated below:]
1. Exhaust Air: [Close][Last position][Open].
 2. Outdoor Air: [Close][Last position][Open].
 3. Supply Air: [Close][Last position][Open].
 4. Return Air: [Close][Last position][Open].
 5. <Insert system and fail-safe position>.

2.11 ELECTRIC AND ELECTRONIC CONTROL-DAMPER ACTUATORS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Belimo Aircontrols (USA), Inc]**
 2. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 3. **[Johnson Controls, Inc.]**
 4. **[Schneider Electric USA, Inc.]**
 5. **[Siemens Industry, Inc., Building Technologies Division]**
 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Belimo Aircontrols (USA), Inc]**
 2. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 3. **[Johnson Controls, Inc.]**
 4. **[Schneider Electric USA, Inc.]**
 5. **[Siemens Industry, Inc., Building Technologies Division]**
 6. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain electric and electronic control-damper actuators from single manufacturer.
- D. Type: Motor operated, with or without gears, electric and electronic.
- E. Voltage:
1. **[See Drawings][Voltage selection is delegated to professional designing control system][24 V][120 V]<Insert requirement>.**
 2. Actuator to deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
 3. Actuator to function properly within a range of 85 to 120 percent of nameplate voltage.
- F. Construction:
1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed-steel enclosures.
 2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains are to be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
 3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- G. Local Field Adjustment: Make spring-return actuators easily switchable from fail-safe open to fail-safe closed in the field without replacement.
- H. Local Manual Override: Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.
- I. Two-Position Actuators: Single direction, spring return or reversing type.
- J. Modulating Actuators:
1. Capable of stopping at all points across full range, and starting in either direction from any point in

range.

2. Control Input Signal:

- a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
- b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for **[0 to 10][or][2 to 10] V dc [and][4 to 20 mA]** signals.
- c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink, or source controller.
- d. Programmable Multifunction:
 - 1) Control input, position feedback, and running time are to be factory or field programmable.
 - 2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
 - 3) Service data, including at a minimum, number of hours powered and number of hours in motion.

K. Position Feedback:

1. **[Equip][Where indicated, equip]** two-position actuators with limit switches or other positive means of a position indication signal for remote monitoring of **[open][and][close]** position.
2. **[Equip][Where indicated, equip]** modulating actuators with a position feedback through **[current][or][voltage]** signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

L. Fail-Safe:

1. Where indicated, provide actuator to fail-safe to an end position.
2. Internal spring-return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other nonmechanical forms of fail-safe operation are acceptable only where uniquely indicated.

M. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

N. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and setscrew method of attachment is acceptable only if provided with at least two points of attachment.

O. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of **[minus 20 to plus 120 deg F (minus 29 to plus 49**

- deg C)]<Insert temperature range>.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range is to be from [5 to 95]<Insert numbers> percent relative humidity, noncondensing.
- P. Enclosure:
1. Suitable for ambient conditions encountered by application.
 2. NEMA 250, [Type 2][or][Type 4] for indoor and protected applications.
 3. NEMA 250, [Type 4][or][Type 4X] for outdoor and unprotected applications.
 4. NEMA 250, [Type 7][or][Type 9] for hazardous applications requiring explosion-proof construction.
 5. Provide actuator enclosure with a heater and controller where required by application.
- Q. Stroke Time:
1. Select operating stroke time to be compatible with equipment and system operation[, and as follows].
 - a. Operate damper from fully closed to fully open position within [15][30][60][75][90][150]<Insert number> seconds.
 - b. Operate damper from fully open to fully closed position within [15][30][60][75][90][150]<Insert number> seconds.
 - c. Move damper to fail-safe position within [5][15][30]<Insert number> seconds.
 2. For actuators operating in smoke-control and other life-safety systems, comply with governing code and NFPA requirements.
- R. Sound: Where actuators are located in tenant-occupied rooms with a room sound-level criteria of [NC-35]<Insert NC level> or lower, comply with the following sound levels:
1. Spring Return: [45]<Insert number> dBA.
 2. Nonspring Return: [45]<Insert number> dBA.
- 2.12 PNEUMATIC CONTROL-DAMPER ACTUATORS
- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [Honeywell Building Solutions; Honeywell International, Inc.]
 2. [Johnson Controls, Inc.]
 3. [Schneider Electric USA, Inc.]
 4. [Siemens Industry, Inc., Building Technologies Division]
 5. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Honeywell Building Solutions; Honeywell International, Inc.]
 2. [Johnson Controls, Inc.]
 3. [Schneider Electric USA, Inc.]
 4. [Siemens Industry, Inc., Building Technologies Division]
 5. <Insert manufacturer's name>
- C. Source Limitations: Obtain pneumatic control-damper actuators from single manufacturer.

- D. Where two or more actuators are installed for interrelated operation in unison, such as dampers used for mixing, provide the dampers with a positive positioner.
- E. Equip pneumatic modulating actuators with a positive positioner, having the following performance characteristics:
 - 1. Linearity: Within **[1]<Insert value>** percent of output signal span.
 - 2. Hysteresis: **[0.5]<Insert number>** percent of the span.
- F. Provide each positioner with an integrally mounted air set and pressure gauges for instrument air supply, instrument input, and positioner output. Operate on a **3 to 15 psig (21 to 103 kPa)** input signal unless otherwise required by the application to comply with the control sequence of operation.
- G. Rate actuators for a pressure of at least **[1.1]<Insert value>** times main supply air pressure to actuator, but not less than **[25 psig (172 kPa)]<Insert pressure>**.
- H. Single-Action (Spring-Return) Diaphragm Actuators:
 - 1. Travel: Rotary or linear travel as required by application.
 - 2. Fail-Safe Position (Loss of Air): Air-to-open or air-to-close, as required by application.
 - 3. Construction:
 - a. Diaphragm: Reinforced synthetic rubber or nitrile. Provide actuators with replaceable diaphragms[**where indicated for the application**].
 - b. Diaphragm Casing and Plate: Cast iron, steel, or cast aluminum.
 - c. Spring, Stem, and Spring Adjuster: Steel or steel alloy.
 - d. Yoke: Cast iron, steel, or cast aluminum.
- I. Double-Action (Air-to-Air) Rack-and-Pinion Actuators:
 - 1. Travel: Rotary travel for control of quarter-turn (zero to 90 degrees) control dampers.
 - 2. Fail-Safe Position (Loss of Air): Last position.
 - 3. Construction:
 - a. Body: Anodized extruded-aluminum alloy.
 - b. End Caps: Cast-aluminum alloy.
 - c. Pistons: Cast-aluminum alloy.
 - d. Piston O-Ring Seals: NBR.
 - e. Output Shaft and Pinion: Zinc-plated carbon steel or stainless steel.
 - f. Travel Stops: Adjustable, stainless steel.
 - g. Fasteners: Stainless steel.
- J. Single-Action (Spring-Return) Rack-and-Pinion Actuators:
 - 1. Travel: Rotary travel for control of quarter-turn (zero to 90 degrees) control dampers.
 - 2. Fail-Safe Position (Loss of Air): Air-to-open or air-to-close, as required by application.
 - 3. Construction:
 - a. Body: Anodized extruded-aluminum alloy.
 - b. End Caps: Cast-aluminum alloy.
 - c. Pistons: Cast-aluminum alloy.
 - d. Piston O-Ring Seals: NBR.
 - e. Output Shaft and Pinion: Zinc-plated carbon steel or stainless steel.
 - f. Springs: Coated steel, steel, or steel alloy.
 - g. Travel Stops: Adjustable, stainless steel.

- h. Fasteners: Stainless steel.
- K. Provide actuator with adjustable stops for both maximum and minimum positions.
- L. Local Manual Override: Where indicated, provide actuators with an external manual adjustment mechanism to allow manual positioning of the damper through the actuator.
- M. Local Position Indication: Provide a position indicator and graduated scale on each actuator. Indicate open and closed travel limits.
- N. Enclosure:
 - 1. Suitable for ambient conditions encountered by application.
 - 2. Install actuator(s) in a supplemental enclosure with a heater and controller where required by application.
- O. Position Feedback Signal:
 - 1. **[Equip][Where indicated, equip]** two-position actuators with limit switches or other positive means of a position indication signal for remote monitoring of **[open][and][close]** position.
 - 2. **[Equip][Where indicated, equip]** modulating actuators with a position feedback through **[current][or][voltage]** signal for remote monitoring.
- P. Stroke Time:
 - 1. Select operating stroke time to be compatible with equipment and system operation[, and as follows].
 - a. Operate damper from fully closed to fully open position within **[15][30]<Insert number>** seconds.
 - b. Operate damper from fully open to fully closed position within **[15][30]<Insert number>** seconds.
 - c. Move damper to fail-safe position within **[5][15][30]<Insert number>** seconds.
 - 2. For actuators operating in smoke-control and other life-safety systems, comply with governing code and NFPA requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL-DAMPER APPLICATIONS

- A. Select from damper types indicated to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
- B. Rectangular Control-Damper Applications:
1. Exhaust Air: **[Rectangular dampers with aluminum airfoil blades][Rectangular dampers with galvanized-steel airfoil blades][Rectangular dampers with stainless steel airfoil blades][Rectangular dampers with aluminum flat blades][Rectangular dampers with galvanized-steel flat blades][Rectangular dampers with stainless steel flat blades]**; <Insert value> maximum air pressure and <Insert value> maximum air velocity.
 2. Outdoor Air: **[Rectangular dampers with aluminum airfoil blades][Rectangular dampers with galvanized-steel airfoil blades][Rectangular dampers with stainless steel airfoil blades][Rectangular dampers with aluminum flat blades][Rectangular dampers with galvanized-steel flat blades][Rectangular dampers with stainless steel flat blades]**; <Insert value> maximum air pressure and <Insert value> maximum air velocity.
 3. Return Air: **[Rectangular dampers with aluminum airfoil blades][Rectangular dampers with galvanized-steel airfoil blades][Rectangular dampers with stainless steel airfoil blades][Rectangular dampers with aluminum flat blades][Rectangular dampers with galvanized-steel flat blades][Rectangular dampers with stainless steel flat blades]**; <Insert value> maximum air pressure and <Insert value> maximum air velocity.
 4. Supply Air: **[Rectangular dampers with aluminum airfoil blades][Rectangular dampers with galvanized-steel airfoil blades][Rectangular dampers with stainless steel airfoil blades][Rectangular dampers with aluminum flat blades][Rectangular dampers with galvanized-steel flat blades][Rectangular dampers with stainless steel flat blades]**; <Insert value> maximum air pressure and <Insert value> maximum air velocity.
- C. Rectangular Control Dampers with Insulated Blade Applications:
1. Exhaust Air: **[Rectangular dampers with insulated aluminum airfoil blades][Rectangular dampers with insulated aluminum airfoil blades and thermal break frames]**; <Insert value> maximum air pressure and <Insert value> maximum air velocity.
 2. Outdoor Air: **[Rectangular dampers with insulated aluminum airfoil blades][Rectangular dampers with insulated aluminum airfoil blades and thermal break frames]**; <Insert value> maximum air pressure and <Insert value> maximum air velocity.
 3. Return Air: **[Rectangular dampers with insulated aluminum airfoil blades][Rectangular dampers with insulated aluminum airfoil blades and thermal break frames]**; <Insert value> maximum air pressure and <Insert value> maximum air velocity.
 4. Supply Air: **[Rectangular dampers with insulated aluminum airfoil blades][Rectangular dampers with insulated aluminum airfoil blades and thermal break frames]**; <Insert value> maximum air pressure and <Insert value> maximum air velocity.
- D. Rectangular Control Dampers with Integral Airflow Applications:
1. Applications with Airflow Measurement: Rectangular dampers with aluminum airfoil blades and integral airflow measurement using **[pressure][or][thermal]** sensing.
 2. Applications with Airflow Control: Rectangular dampers with aluminum airfoil blades and integral airflow control using **[pressure][or][thermal]** sensing.
- E. Rectangular Industrial-Duty Control-Damper Applications:
1. Exhaust Air: **[Rectangular industrial-duty dampers with galvanized-steel airfoil blades][Rectangular industrial-duty dampers with stainless steel airfoil blades]**; <Insert value> maximum air pressure and <Insert value> maximum air velocity.

2. Outdoor Air: **[Rectangular industrial-duty dampers with galvanized-steel airfoil blades][Rectangular industrial-duty dampers with stainless steel airfoil blades]**; **<Insert value>** maximum air pressure and **<Insert value>** maximum air velocity.
3. Return Air: **[Rectangular industrial-duty dampers with galvanized-steel airfoil blades][Rectangular industrial-duty dampers with stainless steel airfoil blades]**; **<Insert value>** maximum air pressure and **<Insert value>** maximum air velocity.
4. Supply Air: **[Rectangular industrial-duty dampers with galvanized-steel airfoil blades][Rectangular industrial-duty dampers with stainless steel airfoil blades]**; **<Insert value>** maximum air pressure and **<Insert value>** maximum air velocity.

F. Round Control-Damper Applications:

1. Exhaust Air: **[Round galvanized steel dampers, sleeve ends][Round stainless steel dampers, sleeve ends][Round galvanized-steel dampers, flange ends][Round stainless steel dampers, flange ends]**; **<Insert value>** maximum air pressure and **<Insert value>** maximum air velocity.
2. Outdoor Air: **[Round galvanized-steel dampers, sleeve ends][Round stainless steel dampers, sleeve ends][Round galvanized-steel dampers, flange ends][Round stainless steel dampers, flange ends]**; **<Insert value>** maximum air pressure and **<Insert value>** maximum air velocity.
3. Return Air: **[Round galvanized-steel dampers, sleeve ends][Round stainless steel dampers, sleeve ends][Round galvanized-steel dampers, flange ends][Round stainless steel dampers, flange ends]**; **<Insert value>** maximum air pressure and **<Insert value>** maximum air velocity.
4. Supply Air: **[Round galvanized-steel dampers, sleeve ends][Round stainless steel dampers, sleeve ends][Round galvanized-steel dampers, flange ends][Round stainless steel dampers, flange ends]**; **<Insert value>** maximum air pressure and **<Insert value>** maximum air velocity.

G. Round Industrial-Duty Control-Damper Applications:

1. Exhaust Air: **[Round carbon steel, industrial-duty dampers][Round, stainless steel, industrial-duty dampers]**; **<Insert value>** maximum air pressure and **<Insert value>** maximum air velocity.
2. Outdoor Air: **[Round carbon steel, industrial-duty dampers][Round, stainless steel, industrial-duty dampers]**; **<Insert value>** maximum air pressure and **<Insert value>** maximum air velocity.
3. Return Air: **[Round carbon steel, industrial-duty dampers][Round, stainless steel, industrial-duty dampers]**; **<Insert value>** maximum air pressure and **<Insert value>** maximum air velocity.
4. Supply Air: **[Round carbon steel, industrial-duty dampers][Round, stainless steel, industrial-duty dampers]**; **<Insert value>** maximum air pressure and **<Insert value>** maximum air velocity.

3.3 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic, wind, or other forces common to the application.
- C. Provide ceiling, floor, roof, **[and]wall openings[, and sleeves]**required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- D. Seal penetrations made in fire-rated and acoustically rated assemblies.

- E. Fastening Hardware:
 - 1. Wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- G. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they will be subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
 - a. Laboratory exhaust airstreams.
 - b. Process exhaust airstreams.
 - c. **<Insert applications>**.
 - 3. Use Type 316 stainless steel tubing and fittings when in contact with a corrosive environment.
 - 4. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 - 5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 CONTROL DAMPERS

- A. Install smooth transitions, not exceeding **[15][30]<Insert number>** degrees, to dampers larger or smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.
- B. Clearance:
 - 1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
 - 2. Install dampers with at least **[24 inches (600 mm)]<Insert distance>** of clear space on sides of dampers requiring service access unless more space is recommended by manufacturer. Provide code required clearances as applicable.
- C. Service Access:
 - 1. Install dampers and actuators to be accessible for visual inspection and service.
 - 2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."
- D. Install dampers straight and true, level in all planes, and square in all dimensions.
- E. Install supplementary structural reinforcement for large multiple-section dampers if factory-furnished

support alone cannot handle loading.

- F. Attach field-installed actuator(s) to damper drive shaft.
- G. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with damper identification on damper[**and on face of ceiling where damper is concealed above ceiling**].

3.6 ELECTRICAL CONNECTIONS

- A. Install electrical power to field-mounted control devices requiring electrical power.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260523 "Control-Voltage Electrical Power Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.7 CONTROL CONNECTIONS

- A. Pneumatic Control Connections: Connect pneumatic control valve actuators and accessories to pneumatic main and signal air. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- B. Install control signal wiring to field-mounted control devices.
- C. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power

Cables."

- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.8 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.9 STARTUP

- A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Verify that control dampers are installed correctly for flow direction.
4. Verify that proper blade alignment, either parallel or opposed, has been provided.
5. Verify that damper frame attachment is properly secured and sealed.
6. Verify that damper actuator and damper linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that damper blade travel is smooth and unobstructed throughout operating range.
9. Pneumatic Control Dampers:
 - a. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
 - b. Verify air supply for each product is properly installed.
 - c. Verify that pressure gauges are provided in each air line to damper actuator and positioner.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.
- C. Check and document open and close cycle times for applications with a cycle time of less than [30]<Insert value> seconds.
- D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 23 09 23 12



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 23 12	23 09 23 00	Direct Digital Control (DDC) System for HVAC
23 09 23 12	23 09 23 00a	Leak Detection Instruments
23 09 23 12	23 09 23 00b	Position Instruments
23 09 23 12	23 09 00 00	Speed Instruments
23 09 23 12	23 09 23 00c	Sequence of Operations for HVAC DDC



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 09 23 13 - ENERGY METERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermal energy meters.
2. Electric power meters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.
3. Section 260913 "Electrical Power Monitoring" for electrical power meters not included in this Section.

1.2 DEFINITIONS

- A.** DDC: Direct-digital control.
- B.** DIN: Deutsche Institut fur Normung (German Institute for Standards).
- C.** DZR: Dezincification resistant.
- D.** Ethernet: Local area network based on IEEE 802.3.1.
- E.** EEPROM: Electrically erasable programmable read-only memory.
- F.** Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.
- G.** I/O: Input/output.
- H.** IP: Ingress protection ratings.
- I.** PEEK: Polyetheretherketone.
- J.** PLC: Programmable logic controller.
- K.** PPS: Polyphenylene sulfide.
- L.** RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
- M.** RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

- N. RS-485: A TIA standard for multipoint communications using two twisted pairs.
- O. RTD: Resistance temperature detector.

1.3 ACTION SUBMITTALS

- A. Product Data: For **[thermal energy meters][electric power meters]**, include the following:
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating electrical power requirements.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.
- B. Sustainable Design Submittals:
 - 1. Product Data for EA Credit 5, "Measurement and Verification": For continuous metering equipment.
 - 2. Product Data for EA Credit "Advanced Energy Metering": For continuous metering equipment.
 - 3. Product Data: For continuous metering equipment for energy consumption.
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and **[mounting]** details.
 - 2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each product and component requiring a certificate.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For energy meters to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 THERMAL ENERGY METERS

- A. Performance Requirements: Manufacturer is to certify that each energy meter complies with specified performance requirements and characteristics.
 - 1. Product certificates are required.
- B. Thermal Energy Meter with Insertion Impeller Flow Sensor:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. **[Badger Meter, Inc.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Badger Meter, Inc.]**
 - b. **<Insert manufacturer's name>**
3. Description:
- a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, user-interface keypad, installation hardware, color-coded interconnecting cabling, and installation instructions.
 - b. Factory calibrate each thermal energy meter and provide with calibration certification.
4. Performance:
- a. Ambient Operating Temperature: **[32 to 130 deg F (0 to 55 deg C)]<Insert temperature range>**.
 - b. Energy Calculation Nonlinearity: Within **[0.05]<Insert number>** percent.
 - c. Flow Sensor Performance:
 - 1) Accuracy: Within **[1]<Insert number>** percent of full-scale range.
 - 2) Flow Velocity Range: **[0.5 to 30 fps (0.15 to 9.1 m/s)]<Insert velocity range>**.
 - 3) Linearity: Within **[0.2]<Insert number>** percent of full-scale range.
 - 4) Repeatability: Within **[0.3]<Insert number>** percent of full-scale range.
 - 5) Pressure Drop: Not to exceed **[1 psig (6.89 kPa)]<Insert value>** at **[20 fps (6.1 m/s)]<Insert value>**.
 - d. Process Pipe Sizes: **NPS 3 (DN 80)** through **[NPS 36 (DN 900)]<Insert pipe size>**.
 - e. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Pressure: Up to **[400 psig (2758 kPa)]<Insert value>**.
 - 2) Temperature: Up to **[221 deg F (105 deg C)]<Insert value>**.
 - f. Process Temperature Accuracy: Differential temperature accuracy within **[0.15 deg F (0.08 deg C)]<Insert temperature>** over the calibrated range.
5. Meter Display: Backlit, LCD alphanumeric display on face of meter enclosure.
- a. Total energy consumption.
 - b. Energy rate.
 - c. Flow rate.
 - d. Total flow consumption.
 - e. Supply temperature.
 - f. Return temperature.
 - g. Visual indication of power status (on/off) on face of enclosure.

6. Meter Electronics Enclosure:
 - a. Remote mounted from temperature and flow sensors.
 - b. Indoor Applications Only: NEMA 250, Type 1.
 - c. Terminal strip for field wiring connections.
 - d. Connections: Suitable for mating to field-installed conduit.
7. Power Supply:
 - a. Field Power: 24 V ac, 50 or 60 Hz as required by the application.
 - b. Internal Power: As required by flow meter.
8. Programming:
 - a. Factory programmed for specific application and field programmable through keypad on face of enclosure.
 - b. Programmed parameters and total energy and flow consumption stored in non-volatile EEPROM memory.
9. Output Signals:
 - a. Total Energy, Flow Consumption: Isolated solid-state dry contact with 100 mA, 50 V rating and pulsed signal.
 - b. Energy Rate, Flow Rate, Supply Temperature, Return Temperature: 4 to 20 mA or zero to 10 V dc for each.
 - c. Option to use serial communication interface in lieu of hardwired signals
10. Serial Communication Interface: Compatible with host to share total energy and flow consumption, energy rate, flow rate, and supply and return temperature data.
11. Flow Sensor:
 - a. Factory Calibration: Calibrate and tag each sensor and provide with a certificate of calibration.
 - b. Wetted Metal Parts, Including Sensor Sleeve, Mounting Adapter, and Isolation Valve: **[Brass, bronze][or][Type 316 stainless steel]**.
 - c. Shaft: **[Tungsten carbide][or][Type 316 stainless steel]**.
 - d. Impeller: **[Nylon][or][ETFE]**.
 - e. Process Connection: **NPS 2 (DN 50)**.
 - f. Insertion Depth: Threaded positioning nut for accurate sensor depth in the pipe.
 - g. Electronics Enclosure:
 - 1) **[PPS][or][PEEK]** with Viton seal.
 - 2) Electrical Connection: Cable furnished with sensor.
 - h. Installation Hardware: Provide installation hardware necessary to enable insertion and removal from the pipe without system shutdown.
 - i. Isolation Valve: Provide sensor with full-port ball valve for system isolation.
 - j. Sensor Cable: As required by manufacturer for field application.
12. Temperature Sensors:
 - a. Enclosure: NEMA 250, Type 4 or equivalent; with conduit connections.
 - b. Sensor Cable: As required by manufacturer for application.
 - c. Sensor Type: **[100-ohm platinum RTD][1000-ohm platinum RTD][or][Type II thermistor]**.

- d. Temperature Range: Matched pair; suitable for application.
- e. Thermowells: Stainless steel; with NPT connections.

C. Thermal Energy Meter with Insertion Turbine Flow Sensor:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Badger Meter, Inc.]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Badger Meter, Inc.]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
3. Description:
 - a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, keypad user interface, installation hardware, color-coded interconnecting cabling, and installation instructions.
 - b. Factory calibrate each thermal energy meter and provide with calibration certification traceable to NIST.
4. Performance:
 - a. Ambient Operating Temperature: **[Minus 20 to 140 deg F (Minus 29 to 60 deg C)]<Insert temperature range>**.
 - b. Energy Calculation Nonlinearity: Within **[0.05]<Insert number>** percent.
 - c. Flow Sensor Accuracy:
 - 1) Within 1 percent of actual flow between the flow velocity range of **[3 to 30 fps (0.9 to 9 m/s)]<Insert velocity range>**.
 - 2) Within 2 percent of actual flow between the flow velocity range of **[0.4 to 20 fps (0.1 to 6.1 m/s)]<Insert velocity range>**.
 - 3) Within **[0.5]<Insert number>** percent of actual reading at the calibrated velocity.
 - d. Flow Sensor Pressure Drop: Not to exceed **[1 psig (6.89 kPa)]<Insert value>** at **[20 fps (6.1 m/s)]<Insert value>** flow velocity in **[NPS 2 (DN 50)]<Insert pipe size>** pipe and decreasing in larger pipe with lower velocity.
 - e. Process Pipe Sizes: **NPS 1-1/4 (DN 32) through [NPS 48 (DN 1200)]<Insert pipe size>**.
 - f. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Pressure: Up to **[400 psig (2758 kPa)]<Insert value>**.
 - 2) Temperature: Within **[25 to 280 deg F (Minus 4 to 138 deg C)]<Insert value>**.
 - g. Process Temperature Accuracy: Differential temperature accuracy within **[0.15 deg F (0.08 deg C)]<Insert temperature>** over the calibrated range.

5. Meter Display: Backlit, LCD alphanumeric display of the following on face of meter enclosure:
 - a. Total energy consumption.
 - b. Energy rate.
 - c. Flow rate.
 - d. Supply temperature.
 - e. Return temperature.
 - f. Visual indication of power status (on/off) on face of enclosure.
6. Meter Electronics Enclosure:
 - a. Remote mounted from temperature and flow sensors.
 - b. Indoor Applications: NEMA 250, Type 4 or 13.
 - c. Outdoor Applications: NEMA 250, Type 4.
 - d. Labeled terminal strip for field wiring connections.
 - e. Connections: Suitable for mating to field-installed conduit.
7. Power Supply:
 - a. Field Power: 24, 120, 240 V ac, 50 or 60 Hz as required by the application.
 - b. Internal Power: As required by flow meter.
8. Programming:
 - a. Factory programmed for specific application and field programmable through keypad on face of enclosure.
 - b. Programmed parameters and total energy consumption stored in non-volatile EEPROM memory.
9. Output Signals:
 - a. Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50 V rating and contact duration of 0.5, 1, 2, or 6 seconds.
 - b. Energy Rate, Flow Rate, Supply Temperature, Return Temperature: 4 to 20 mA or zero to 10 V dc for each.
 - c. Option to use serial communication interface in lieu of hardwired signals
10. Serial Communication Interface: Compatible with host to share total energy consumption, energy rate, flow rate, and supply and return temperature data.
11. Flow Sensor:
 - a. Factory Calibration: Wet calibrate and tag each sensor to standards traceable to NIST, and provide each sensor with a certificate of calibration.
 - b. Turbines:
 - 1) Single turbine sensors for pipe sizes **NPS 1-1/4 through NPS 2 (DN 32 through DN 50)**.
 - 2) Dual turbine sensors for pipe sizes **NPS 2-1/2 (DN 65)** and larger.
 - 3) Bidirectional dual turbine sensors where installed in bypass piping of size **NPS 2-1/2 (DN 65)** and larger.
 - 4) Dual sensors with dual contra-rotating turbine elements; each turbine element with its own rotational sensing system and an averaging circuit to reduce measurement errors due to a poor flow profile.
 - 5) Rotational sensing of each turbine accomplished electronically by sensing impedance change with an integral frequency output linear with flow rate and

- individual top and bottom turbine outputs for diagnostic purposes.
 - 6) Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts.
 - c. Construction: Wetted metal components of Type 316 stainless steel[**or bronze and nickel plated brass**], including the installation hardware.
 - d. Enclosure: House sensor electronics in a NEMA 250, Type 4 weathertight aluminum enclosure with a gasketed cover and conduit connections.
 - e. Installation Hardware: Provide installation hardware necessary to enable insertion and removal from the pipe without system shutdown.
 - f. Isolation Valve: Provide sensor with full-port [**Type 316 stainless steel**]ball valve for system isolation.
 - g. Sensor Cable: As required by manufacturer for field application.
12. Temperature Sensors:
 - a. Enclosure: NEMA 250, Type 4 with conduit connections.
 - b. Sensor Cable: As required by manufacturer for application.
 - c. Temperature Range: Matched pair; suitable for application.
 - d. Thermowells: Stainless steel; with NPT connections.
- D. Thermal Energy Meter with Insertion Electromagnetic Flow Sensor:
 1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. [**Badger Meter, Inc.**]
 - b. [**Dwyer Instruments, Inc**]
 - c. [**ONICON Incorporated**]
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [**Badger Meter, Inc.**]
 - b. [**Dwyer Instruments, Inc**]
 - c. [**ONICON Incorporated**]
 - d. **<Insert manufacturer's name>**
 3. Description:
 - a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, keypad user interface, installation hardware, color-coded interconnecting cabling, and installation instructions.
 - b. Factory calibrate each thermal energy meter and provide with calibration certification traceable to NIST.
 4. Performance:
 - a. Ambient Operating Temperature: [**Minus 20 to 140 deg F (Minus 29 to 60 deg C)**]**<Insert temperature range>**.
 - b. Energy Calculation Nonlinearity: Within [**0.05**]**<Insert number>** percent.
 - c. Fluid Electrical Conductivity: Suitable for fluids with electrical conductivity between 20 to

- d. 60000 microseimens per centimeter.
Flow Sensor Accuracy:
 - 1) Accuracy for velocities between [2 and 20 fps (0.6 to 6.1 m/s)]<Insert velocity range> to be within [1]<Insert number> percent of reading.
 - 2) Accuracy for velocities less than [2 fps (0.6 m/s)]<Insert velocity> to be within [0.02 fps (0.006 m/s)]<Insert velocity>.
 - e. Flow Sensor Pressure Drop: Not to exceed [0.1 psig (0.7 kPa)]<Insert value> at [12 fps (3.7 m/s)]<Insert value> flow velocity in [NPS 3 (DN 80)]<Insert pipe size> pipe and decreasing in larger pipe with lower velocity.
 - f. Flow Sensor Velocity Range: [0.25 to 20 fps (0.08 to 6.1 m/s)]<Insert flow velocity range>.
 - g. Process Pipe Sizes: NPS 1-1/4 (DN 32) through [NPS 48 (DN 1200)]<Insert pipe size>.
 - h. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Pressure: Up to [400 psig (2758 kPa)]<Insert value>.
 - 2) Temperature: Within [25 to 250 deg F (Minus 4 to 121 deg C)]<Insert value>.
 - i. Process Temperature Accuracy: Differential temperature accuracy within [0.15 deg F (0.08 deg C)]<Insert temperature> over the calibrated range.
5. Meter Display: Backlit, LCD alphanumeric display of the following on face of meter enclosure:
- a. Total energy consumption.
 - b. Energy rate.
 - c. Flow rate.
 - d. Supply temperature.
 - e. Return temperature.
 - f. Visual indication of power status (on/off) on face of enclosure.
6. Meter Electronics Enclosure:
- a. Remote mounted from temperature and flow sensors.
 - b. Indoor Applications: NEMA 250, Type 4 or 13.
 - c. Outdoor Applications: NEMA 250, Type 4.
 - d. Labeled terminal strip for field wiring connections.
 - e. Connections: Suitable for mating to field-installed conduit.
7. Power Supply:
- a. Field Power: 24, 120, 240 V ac, 50 or 60 Hz as required by the application.
 - b. Internal Power: As required by flow meter.
8. Programming:
- a. Factory programmed for specific application and field programmable through keypad on face of enclosure.
 - b. Programmed parameters and total energy consumption stored in non-volatile EEPROM memory.
9. Output Signals:
- a. Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50 V rating and

- contact duration of 0.5, 1, 2, or 6 seconds.
 - b. Energy Rate, Flow Rate, Supply Temperature, Return Temperature: 4 to 20 mA or zero to 10 V dc for each.
 - c. Option to use serial communication interface in lieu of hardwired signals
- 10. Serial Communication Interface: Compatible with host to share total energy consumption, energy rate, flow rate, and supply and return temperature data.
- 11. Flow Sensor:
 - a. Factory Calibration: Wet calibrate and tag each sensor to standards traceable to NIST, and provide each sensor with a certificate of calibration.
 - b. Sensor Head: Polysulfone.
 - c. Construction: Wetted metal components of Type 316 stainless steel, including the installation hardware.
 - d. Enclosure: House electronics in a NEMA 250, Type 4 weathertight aluminum enclosure with a gasketed cover and conduit connections.
 - e. Installation Hardware: Provide installation hardware necessary to enable insertion and removal from the pipe without system shutdown.
 - f. Isolation Valve: Provide sensor with full-port Type 316 stainless steel ball valve for system isolation.
 - g. Sensor Cable: As required by manufacturer for application.
- 12. Temperature Sensors:
 - a. Enclosure: NEMA 250, Type 4 with conduit connections.
 - b. Sensor Cable: As required by manufacturer for application.
 - c. Temperature Range: Matched pair; suitable for application.
 - d. Thermowells: Stainless steel; with NPT connections.
- E. Thermal Energy Meter with In-Line Electromagnetic Flow Sensor:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
 - 3. Description:
 - a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, keypad user interface, installation hardware, color-coded interconnecting cabling, and installation instructions.
 - b. Factory calibrate each thermal energy meter and provide with calibration certification traceable to NIST.

4. Performance:
 - a. Ambient Operating Temperature: [Minus 20 to 140 deg F (Minus 29 to 60 deg C)]<Insert temperature range>.
 - b. Energy Calculation Nonlinearity: Within [0.05]<Insert number> percent.
 - c. Fluid Electrical Conductivity: Suitable for fluids with electrical conductivity greater than 5 microseimens per centimeter.
 - d. Flow Sensor Accuracy:
 - 1) Accuracy for velocities between [2 and 20 fps (0.6 to 6.1 m/s)]<Insert velocity range> to be within [0.2][0.5]<Insert number> percent of reading.
 - 2) Accuracy for velocities less than [2 fps (0.6 m/s)]<Insert velocity> to be within [0.0004 fps (0.001 m/s)]<Insert velocity>.
 - e. Flow Sensor Pressure Drop: No permanent pressure drop.
 - f. Flow Sensor Velocity: [0.1 to 20 fps (0.03 to 6.1 m/s)]<Insert flow velocity range>.
 - g. Process Pipe Sizes: NPS 1 (DN 25) through [NPS 48 (DN 1200)]<Insert pipe size>.
 - h. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Pressure: Up to [225 psig (1551 kPa)][580 psig (3999 kPa)]<Insert value>.
 - 2) Temperature: Within [25 to 250 deg F (Minus 4 to 121 deg C)]<Insert value>.
 - i. Process Temperature Accuracy: Differential temperature accuracy within [0.15 deg F (0.08 deg C)]<Insert temperature> over the calibrated range.
5. Meter Display: Backlit, LCD alphanumeric display of the following on face of meter enclosure:
 - a. Total energy consumption.
 - b. Energy rate.
 - c. Flow rate.
 - d. Supply temperature.
 - e. Return temperature.
 - f. Visual indication of power status (on/off) on face of enclosure.
6. Meter Electronics Enclosure:
 - a. Remote mounted from temperature and flow sensors.
 - b. Indoor Applications: NEMA 250, Type 4 or 13.
 - c. Outdoor Applications: NEMA 250, Type 4.
 - d. Labeled terminal strip for field wiring connections.
 - e. Connections: Suitable for mating to field-installed conduit.
7. Power Supply:
 - a. Field Power: 24, 120, 240 V ac, 50 or 60 Hz as required by the application.
 - b. Internal Power: As required by flow meter.
8. Programming:
 - a. Factory programmed for specific application and field programmable through keypad on face of enclosure.
 - b. Programmed parameters and total energy consumption stored in non-volatile EEPROM memory.

9. Output Signals:
 - a. Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50 V rating and contact duration of 0.5, 1, 2, or 6 seconds.
 - b. Energy Rate, Flow Rate, Supply Temperature, Return Temperature: 4 to 20 mA or zero to 10 V dc for each.
 - c. Option to use serial communication interface in lieu of hardwired signals.
 10. Serial Communication Interface: Compatible with host to share total energy consumption, energy rate, flow rate, and supply and return temperature data.
 11. Flow Sensor:
 - a. Factory Calibration: Wet calibrate and tag each sensor to standards traceable to NIST, and provide each sensor with a certificate of calibration.
 - b. Body Connection: **[Flange, suitable for mating to adjacent pipe flange][or][wafer]**.
 - c. Body Material: **[Epoxy-coated carbon steel][Type 316 stainless steel]**.
 - d. Body Liner Material: **[PTFE][Ebonite][Polypropylene]**.
 - e. Flow Tube: Type 304 or 316 stainless steel.
 - f. Electrodes: Type 316 stainless steel. Quantity determined by manufacturer based on application.
 - g. Enclosure: House electronics in a NEMA 250, Type 4 enclosure with conduit connections.
 - h. Sensor Cable: As required by manufacturer for application.
 12. Temperature Sensors:
 - a. Enclosure: NEMA 250, Type 4 with conduit connections.
 - b. Sensor Cable: As required by manufacturer for application.
 - c. Temperature Range: Matched pair; suitable for application.
 - d. Thermowells: Stainless steel; with NPT connections.
- F. Thermal Energy Meter, Compact Type, with In-Line Ultrasonic Flow Sensor:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
 3. Description:
 - a. Flow Sensing Method: No moving parts; direct beam path wetted ultrasonic sensors utilizing differential transit time velocity measurement.
 - b. Meter Size Range: **[NPS 1/2 (DN 13)]<Insert pipe size>** through **[NPS 2-1/2 (DN 65)]<Insert pipe size>**.
 - c. Factory Calibration:

- 1) Factory calibrate each meter against manufacturer's NIST-traceable flow standards and provide a certificate of calibration for each meter.
 - 2) Factory calibrate temperature sensors against manufacturer's standards and provide a certificate of calibration.
 - d. Programming:
 - 1) Configure and program each meter at factory for specific application without need for field programming. Field programming is available through the user interface or through the serial interface using an operator workstation.
 - 2) Store program parameters and totalized values in nonvolatile flash memory.
 - e. Battery: Back-up real-time clock and calendar with lithium battery.
 - f. Approvals: BTL certified in accordance with ASHRAE 135.
4. Performance:
 - a. Energy calculations computation error of less than **[0.09]<Insert number>** percent with a temperature differential of **[30 deg F (17 deg C)]<Insert temperature>**.
 - b. Repeatability: Within 0.2 percent.
 - c. Ambient Temperature: **[Minus 10 to 130 deg F (Minus 23 to 54 deg C)]<Insert value>**.
 - d. Ambient Humidity: 5 to 90 percent relative humidity, noncondensing.
 - e. Flow accuracy of 1 percent for flow range:
 - 1) NPS 1/2 (DN 13): **[0.6 to 15 gpm (0.038 to 0.95 L/s)]<Insert flow range>**.
 - 2) NPS 3/4 (DN 20): **[0.6 and 15 gpm (0.038 and 0.95 L/s)]<Insert flow range>**.
 - 3) NPS 1 (DN 25): **[1 to 25 gpm (0.063 to 1.58 L/s)]<Insert flow range>**.
 - 4) NPS 1-1/4 (DN 32): **[3 to 60 gpm (0.189 to 3.78 L/s)]<Insert flow range>**.
 - 5) NPS 1-1/2 (DN 40): **[5 to 100 gpm (0.315 to 6.31 L/s)]<Insert flow range>**.
 - 6) NPS 2 (DN 50): **[8 to 150 gpm (0.505 to 9.46 L/s)]<Insert flow range>**.
 - 7) NPS 2-1/2 (DN 65): **[12 to 225 gpm (0.757 to 14.19 L/s)]<Insert flow range>**.
 - f. Flow accuracy of 2 percent for flow range:
 - 1) NPS 1/2 (DN 13): **[0.15 and 0.6 gpm (0.0009 and 0.038 L/s)]<Insert flow range>**.
 - 2) NPS 3/4 (DN 20): **[0.15 and 0.6 gpm (0.009 and 0.038 L/s)]<Insert flow range>**.
 - 3) NPS 1 (DN 25): **[0.25 and 1.0 gpm (0.016 and 0.063 L/s)]<Insert flow range>**.
 - 4) NPS 1-1/4 (DN 32): **[0.6 and 3.0 gpm (0.038 and 0.189 L/s)]<Insert flow range>**.
 - 5) NPS 1-1/2 (DN 40): **[1.0 and 5.0 gpm (0.063 and 0.315 L/s)]<Insert flow range>**.
 - 6) NPS 2 (DN 50): **[1.5 and 8.0 gpm (0.095 and 0.505 L/s)]<Insert flow range>**.
 - 7) NPS 2-1/2 (DN 65): **[2.5 and 12 gpm (0.158 and 0.758 L/s)]<Insert flow range>**.
 - g. Minimum Flow Rate:
 - 1) NPS 1/2 (DN 13): **[0.03 gpm (0.002 L/s)]<Insert value>**.
 - 2) NPS 3/4 (DN 20): **[0.03 gpm (0.002 L/s)]<Insert value>**.
 - 3) NPS 1 (DN 25): **[0.05 gpm (0.003 L/s)]<Insert value>**.
 - 4) NPS 1-1/4 (DN 32): **[0.12 gpm (0.008 L/s)]<Insert value>**.
 - 5) NPS 1-1/2 (DN 40): **[0.20 gpm (0.013 L/s)]<Insert value>**.
 - 6) NPS 2 (DN 50): **[0.30 gpm (0.019 L/s)]<Insert value>**.
 - 7) NPS 2-1/2 (DN 65): **[0.50 gpm (0.032 L/s)]<Insert value>**.
 - h. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.

- 1) Pressure: Up to [400 psig (2758 kPa)]<Insert value>.
 - 2) Temperature: Within [32 to 250 deg F (0 to 121 deg C)]<Insert value>.
- i. Process Temperature Accuracy:
 - 1) Each Sensor: Within [0.25 deg F (0.14 deg C)]<Insert value>.
 - 2) Differential: Within [0.18 deg F (0.10 deg C)]<Insert value>.
- j. Pressure Drop: [1.5 psig (10 kPa)]<Insert value> or less at following flow rate:
 - 1) NPS 1/2 (DN 13): [6.6 gpm (0.42 L/s)]<Insert value>.
 - 2) NPS 3/4 (DN 20): [6.6 gpm (0.42 L/s)]<Insert value>.
 - 3) NPS 1 (DN 25): [11 gpm (0.69 L/s)]<Insert value>.
 - 4) NPS 1-1/4 (DN 32): [26 gpm (1.64 L/s)]<Insert value>.
 - 5) NPS 1-1/2 (DN 40): [44 gpm (2.78 L/s)]<Insert value>.
 - 6) NPS 2 (DN 50): [66 gpm (4.16 L/s)]<Insert value>.
 - 7) NPS 2-1/2 (DN 65): [110 gpm (6.94 L/s)]<Insert value>.
5. Network Connection:
 - a. TIA RS-485 serial interface.
 - b. ASHRAE 135, native BACnet MS/TP protocol.
 - c. Communicates energy consumption and rate, flow rate, supply and return temperature, peak and average values, interval data and network status.
6. Input Signals:
 - a. Three isolated totalizing pulse inputs for use with sinking open collector or dry contacts.
 - b. Rating: 30 V dc, 10-milliamp maximum.
 - c. Pulse duration of 50 milliseconds.
 - d. For use in totalizing pulses from external devices.
 - e. Totals accumulated at the meter, displayed locally and remotely through the network connection.
7. Display and Calculator:
 - a. Integral to meter and detachable for remote field mounting.
 - b. Backlight alphanumeric display and operator interface.
 - c. Same information communicated to network available on the display.
8. Meter:
 - a. Enclosure:
 - 1) Polycarbonate with removable screw-on cover.
 - 2) Rating: IEC 60529 IP65 or NEMA 250, Type 4.
 - 3) Electrical Connections: Labeled screw terminals.
 - 4) Conduit Connections: Two; trade size.
 - b. End Connections:
 - 1) Sizes through NPS 2 (DN 50): Threaded, MNPT.
 - 2) NPS 2-1/2 (DN 65): Flange face for mating to ASME B16.5, Class 150 raised face flange.
 - c. Wetted Materials: Lead-free brass containing not more than 15 percent zinc (DZR and

corrosion resistant), PEEK.

9. Power Supply:

- a. Field Power: 24 V ac, 50 or 60 Hz unless otherwise required by the application.

10. Temperature Sensors:

- a. Field-serviceable, matched pair of two-wire, 1000-ohm platinum RTDs.
- b. Provide one temperature sensor built into meter body for sizes through [NPS 1 (DN 25)]<Insert pipe size> and provide second sensor with threaded thermowell and threaded sensor connection for insertion in field piping.
- c. For larger meter sizes, provide supply and return sensors with threaded thermowell and threaded sensor connection for insertion in field piping.
- d. Thermowells: Brass for installation in copper tubing and stainless steel for installation in all other piping.

G. Thermal Energy Meter with Clamp-On Ultrasonic Flow Sensor:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. **[Badger Meter, Inc.]**
- b. **[Dwyer Instruments, Inc]**
- c. **[ONICON Incorporated]**
- d. **<Insert manufacturer's name>**

- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Badger Meter, Inc.]**
- b. **[Dwyer Instruments, Inc]**
- c. **[ONICON Incorporated]**
- d. **<Insert manufacturer's name>**

3. Description:

- a. Flow Sensing Method: Non-invasive with no moving parts; ultrasonic differential transit time velocity measurement using nonwetted transducers. Method is suitable for use with clear fluids in pressurized metallic and nonmetallic pipes that are full.
- b. Factory Wet Calibration:
 - 1) Factory calibrate each meter against manufacturer's NIST-traceable flow standards and provide a certificate of calibration for each meter.
 - 2) Factory calibrate temperature sensors against manufacturer's standards and provide a certificate of calibration.
- c. Programming:
 - 1) Configure and program each meter at factory for specific application without need for field programming. Field programming is available through the user interface or through the serial interface using an operator workstation.

- 2) Store program parameters and totalized values in nonvolatile memory.
- d. Battery: Back-up real-time clock and calendar with lithium battery.
- e. Data Logger: Integral data log with minimum [128]<Insert value> MB of storage.
4. Performance:
 - a. Ambient Humidity: 5 to 90 percent relative humidity, noncondensing.
 - b. Ambient Operating Temperature: [Minus 5 to 140 deg F (Minus 21 to 60 deg C)]<Insert temperature range>.
 - c. Energy calculations computation error of less than [0.09]<Insert number> percent with a temperature differential of [30 deg F (17 deg C)]<Insert temperature>.
 - d. Repeatability: Within [0.25]<Insert number> percent.
 - e. Flow Sensor Accuracy:
 - 1) Accuracy for velocities between [1 and 20 fps (0.3 to 6.1 m/s)]<Insert velocity range> to be within [1]<Insert number> percent of reading.
 - 2) Accuracy for velocities less than [1 fps (0.3 m/s)]<Insert velocity> to be within [0.01 fps (0.003 m/s)]<Insert velocity>.
 - f. Flow Sensor Pressure Drop: No permanent pressure drop.
 - g. Flow Sensor Velocity Range: [0.07 to 40 fps (0.02 to 12.2 m/s)]<Insert flow velocity range>.
 - h. Process Pipe Sizes: NPS 1/2 (DN 13) through [NPS 48 (DN 1200)]<Insert pipe size>.
 - i. Process Temperature: Suitable for system maximum operating temperature.
 - 1) Temperature: Within [Minus 40 to 250 deg F (Minus 40 to 121 deg C)]<Insert value>.
 - j. Process Temperature Accuracy:
 - 1) Each Sensor: Within [0.25 deg F (0.14 deg C)]<Insert value>.
 - 2) Differential: Within [0.18 deg F (0.10 deg C)]<Insert value>.
5. Meter Display and Operator Interface: Backlit, LCD alphanumeric display of the following on face of meter enclosure:
 - a. Total energy consumption.
 - b. Energy rate.
 - c. Flow rate.
 - d. Supply temperature.
 - e. Return temperature.
 - f. Visual indication of power status (on/off) on face of enclosure.
6. Meter Enclosure:
 - a. Remote mounted from temperature and flow sensors.
 - b. Rating: IEC 60529 IP67 or NEMA 250, Type 4X.
 - c. Construction: Polycarbonate with hinged cover.
 - d. Electrical and Control Cable Connections: Labeled screw terminals.
 - e. Conduit Connections: Manufacturer standard; trade size suitable for mating to field-installed conduit.
7. Input Signals:
 - a. Three isolated totalizing pulse inputs for use with sinking open collector or dry contacts.

- b. Rating: 30 V dc, 10-milliamp maximum.
 - c. Pulse duration of 50 milliseconds.
 - d. For use in totalizing pulses from external devices.
 - e. Totals accumulated at the meter, displayed locally and remotely through the network connection.
- 8. Output Signals:
 - a. Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50 V rating with pulse.
 - b. Energy Rate, Flow Rate, Supply Temperature, Return Temperature: 4 to 20 mA or zero to 10 V dc for each.
- 9. Serial Network Interface:
 - a. TIA RS-485 serial interface for remoted monitoring.
 - b. ASHRAE 135, native BACnet MS/TP protocol.
 - c. Communicate energy consumption and rate, flow rate, supply and return temperature, peak and average values, interval data, and network status.
- 10. Power Supply:
 - a. Field Power: 24, 120, 240 V ac, 50 or 60 Hz as required by the application.
 - b. Internal Power: As required by flow meter.
- 11. Temperature Sensors:
 - a. Field-serviceable, matched pair of two-wire, 1000-ohm platinum RTDs. Supply and return sensors have threaded thermowell and threaded sensor connection for insertion in field piping.
 - b. Enclosure: NEMA 250, Type 4 with conduit connections.
 - c. Sensor Cable: As required by manufacturer for application.
 - d. Temperature Range: Suitable for application.
 - e. Thermowells: Stainless steel; with NPT connections.
- 12. Transducers:
 - a. Housing: Type 316 stainless steel; NEMA 250, Type 4 with trade-size conduit connections.
 - b. Mounting Kit: Type 304 or 316 stainless steel brackets and miscellaneous hardware; option to use 200 series stainless steel clamps.
 - c. Sensor Cable: As required by manufacturer for application.

2.2 ELECTRIC POWER METERS

- A. Performance Requirements: Manufacturer is to certify that each electric power meter complies with specified performance requirements and characteristics. Certificate is required.
- B. Electric Power Meter - Basic:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. [Eaton]
 - b. [Omron Americas]
 - c. [Siemens Industry, Inc., Building Technologies Division]
 - d. [Square D; Schneider Electric USA]
 - e. [Veris Industries]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Eaton]
 - b. [Omron Americas]
 - c. [Siemens Industry, Inc., Building Technologies Division]
 - d. [Square D; Schneider Electric USA]
 - e. [Veris Industries]
 - f. <Insert manufacturer's name>
3. Description: Separately mounted, permanently installed, electronic power meter.
 - a. Capable of metering four-wire wye, three-wire delta, and single-phase power systems.
 - b. For renewable energy applications, meters to include bidirectional monitoring and measurement of imported and exported power.
 - c. Include with current transformers and transducers suitable for the application.
4. Features:
 - a. Measured energy consumption stored in nonvolatile memory.
 - b. Programmable demand measurements for multiple intervals and varying durations.
 - c. Automatic phase reversal compensation so insensitive to CT load orientation.
 - d. Separate control power inputs so meter can be powered from a different power source than the power service being measured.
 - e. Configurable for use with different potential transformers.
 - f. Data Recording: Store values in nonvolatile memory; indicate which of the three phases relates to the value. Attach a date and time stamp to the peak values and the alarms.
 - g. Alarms: Transmit an output signal and show on display when alarmed. Provide for no fewer than [3]<Insert number> metered items.
 - h. Listed in accordance with UL 508.
5. Measurements:
 - a. Accumulated Real Energy (kWh): For each phase and total of all phases.
 - b. Accumulated Reactive Energy (kVARh): Total for all phases.
 - c. Apparent Energy (kVAh): Totals for all phases.
 - d. Net Present Demand for Real (kW), Reactive (kVAR) and Apparent (kVA) Power: Over a user-specified interval (block or sliding window).
 - e. Maximum (peak) real (kW), reactive (kVAR) and apparent (kVA) demand intervals.
 - f. Instantaneous Real (kW), Reactive (kVAR) and Apparent Power (kVA): By phase and in total.
 - g. Current (amps) for each phase and average of all phases.
 - h. Phase-to-phase voltage for each phase and average of all phase pairs.
 - i. Phase-to-neutral voltage for each phase pair and average of all phases.
 - j. Power factor for each phase and average of all phases.
 - k. AC frequency.
6. Performance:

- a. Accuracy: **[Comply with ANSI C12.20, Class 0.5 and IEC 62053-22, Class 0,2S]<Insert requirements>**.
 - b. Ambient Humidity: Less than 95 percent, noncondensing.
 - c. Ambient Temperature: **[Minus 10 to 130 deg F (Minus 23 to 54 deg C)]<Insert value>**.
 - d. Current:
 - 1) Rated Primary: **[5 to 600]<Insert range> A**.
 - 2) Scaled: **[5 to 32000]<Insert range> A**.
 - e. Measured Voltage: **[90 to 600]<Insert range> V ac, 50 or 60 Hz**.
7. Enclosure:
- a. Indoor Applications: NEMA 250, Type 1; **DIN rail mount in accordance with IEC 60715 (EN)**.
 - b. Outdoor Applications: NEMA 250, Type 4 or 4X.
8. Display: Backlit LCD showing measured values, alarm functions, and outputs.
9. Digital Output Signals:
- a. Alarm: Normally closed.
 - b. Real Energy: Pulse (normally open).
10. Serial Communication Interface: TIA RS-485 2-wire connection; **[BACnet MS/TP][and][or][Modbus RTU]** protocol.

C. Electric Power Meter - Multifunction, Fully Programmable:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Allen Bradley; by Rockwell Automation]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Building Technologies Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Allen Bradley; by Rockwell Automation]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Building Technologies Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
3. Hardware:
- a. Voltage Inputs:
 - 1) **[Three]<Insert value>** voltage inputs, capable of measuring from zero to 347 V rms (line to neutral) or from zero to 600 V rms (line to line).

- 2) Provisions for direct connection to wye (star) systems up to 347/600 V ac. For higher voltage systems, use power transformers with 120, 277, or 347 V ac secondaries.
- 3) Voltage inputs with the following:
 - a) 1500 V ac continuous surge protection.
 - b) 25 percent of full-scale voltage over range capability.
- b. Current Inputs:
 - 1) **[Three]<Insert value>**; 5 A nominal (10 A full-scale).
 - 2) Transformer coupled and accepting CTs with 5 A nominal (10 A full-scale) outputs.
 - 3) Current inputs with the following:
 - a) 300 A surge protection for one second.
 - b) 25 percent of full-scale current continuous over range capability.
- c. Power Supply:
 - 1) Voltage: 95 to 240 V ac (within 10 percent) at 47 to 440 Hz, 110 to 300 V dc, or 20 to 60 V dc power source.
 - 2) Load: Not to exceed 12 W.
- d. On-board I/O:
 - 1) **[Four]<Insert value>** digital (status) inputs.
 - 2) **[Four]<Insert value>** optically isolated, digital (status) outputs with the following features:
 - a) Outputs with ability to provide pulse outputs according to any energy consumption levels.
 - b) Scalable units per pulse.
 - 3) **[Four]<Insert value>** analog I/O operator selectable from:
 - a) Milliamp inputs.
 - b) Zero to 20 mA inputs.
 - c) Four zero to 1 mA outputs.
 - d) Four zero to 20 mA outputs.
 - e) Four zero to 1 mA inputs and four zero to 1 mA outputs.
 - f) Four zero to 20 mA inputs and four zero to 20 mA outputs.
 - 4) Analog inputs and outputs accurate to within **[0.3]<Insert number>** percent of full scale.
- e. Provisions for Future External I/O: Support up to **[four]<Insert value>** digital output devices and the following devices:
 - 1) 120 V ac, 3.5 A, NO solid-state relay.
 - 2) 120 V ac, 3.5 A, zero voltage turn-on, manual override relay.
 - 3) 240 V ac, 3.5 A, NO solid-state relay.
 - 4) 240 V ac, 3.5 A, zero voltage turn-on, manual override relay.
 - 5) 60 V dc, 3.5 A, NO solid-state relay.
 - 6) 60 V dc, 1.5 mA, zero voltage turn-on, manual override relay.
 - 7) 60 V dc, 1.0 A, low-leakage, NO solid-state relay.
 - 8) 200 V dc, 1.0 A, NO solid-state relay.
 - 9) 100 V dc, 0.5 A, NO mechanical relay.

- f. Communications:
- 1) Provide the following built-in communication ports of standard technology, as defined by IEEE:
 - a) **[Two]<Insert value>** optically isolated RS-485 communication ports, supporting data rates from 1200 to **[19,200]<Insert value>** bits per second.
 - b) One front-panel infrared optical port for TIA RS-232 communications, supporting data rates from 1200 to **[19,200]<Insert value>** bits per second as well as an ANSI Type II optocoupler.
 - c) Ethernet port with gateway that allows the host system to communicate through the Ethernet port to additional metering devices connected to the card's communication port. Include provisions for an internal Ethernet port compatible with 10Base-T Ethernet. Terminate Ethernet port using an RJ-45 connector.
 - 2) Support the following communication capabilities, independently configurable:
 - a) Modbus RTU **[and][or][BACnet MS/TP]** protocol.
 - b) Simultaneous access through all communication ports to any measured or derived parameter.
 - c) Field-configurable protocols from the front display, or via communication ports, and be capable of being accomplished without resetting the meter or interrupting its operation in any way.
 - d) Provisions for flash firmware that can be field upgraded through any communication port, without de-commissioning the instrument or de-energizing the circuit or equipment. Firmware-upgrade procedure is able to recover from power failure during an upgrade.
 - e) Support time synchronization broadcast messages from a host computer system.
- g. Mounting Options:
- 1) Panel cutout, using sliding clamps tightened by thumbscrews.
 - 2) Transducer-type base unit with a remote backlit digital display, with cable for remote display applications.
 - 3) Transducer-type base unit, locally mounted.
 - 4) Allow operator to remove and replace the display panel without removing the instrument from the equipment in which it is mounted.
- h. Front-Panel Display:
- 1) Programmable buttons that allow access to **[eight]<Insert value>** data display screens.
 - 2) Display measured parameter with its corresponding label.
 - 3) Display any **[four]<Insert value>** parameters simultaneously using alphanumeric characters.
 - 4) Display any **[two]<Insert value>** parameters simultaneously using large alphanumeric characters.
 - 5) Display any parameter using very large alphanumeric characters.
 - 6) Display basic voltage, current, and power readings using extra-large alphanumeric characters.
 - 7) Give operator ability to change parameter labels.
 - 8) Feature a programmable time-out interval and adjustable contrast.

- i. Enclosure: If installation requires meter to be installed in a dedicated enclosure, install meter in an NRTL-listed enclosure suitable for operating environment at meter location.
 - 1) Indoors: NEMA 250, [Type 1][or][Type 12].
 - 2) Outdoors: NEMA 250, [Type 4][or][Type 4X].
- j. Memory: Non-volatile memory to store the following:
 - 1) Setup data.
 - 2) A time-stamped event log with the following features:
 - 3) Support at least [500]<Insert value> events.
 - a) Number of records in the log to be programmable.
 - b) Record the date and time of each event, the cause and effect of the event, and the priority of the event.
 - c) Record events relating to set-point activity, relay operation, and self-diagnostics in the event log.
 - d) Time stamps with resolution of one millisecond.
 - e) Synchronize time stamps to within 100 ms between devices on the same serial communication medium.
 - f) Minimum event recording response time of one second.
 - g) Programmable priority of set-point events.
 - 4) [Two]<Insert value> programmable data recorders that can each store up to [16]<Insert value> channels of historical trend data with the following features:
 - a) Each data recorder able to record any parameter, either measured or derived.
 - b) Enabled and trigger each data recorder manually or through internal operating conditions, including periodic timer or set-point activity.
 - c) Program the number of records (depth) of each data recorder and the overflow conditions (stop-when-full or circular).
 - d) Memory dynamically allocated between data recorders and event log to allow storage of any [16]<Insert value> parameters at [15]<Insert value>-minute intervals for not less than 30 days.
 - 5) Min/Max data for any monitored parameter.
- 4. Meter:
 - a. Display web pages over a standard Internet browser and include real-time instantaneous values, accumulated energy values, and total harmonic distortion.
 - b. Automatically e-mail alarm notifications or scheduled system status updates. Send e-mail messages for receipt as ordinary e-mail message.
 - c. Send data logs on an event-driven or scheduled basis.
 - d. Accommodate high-speed [Modbus TCP/IP][or][BACnet IP]<Insert type> communications when connected to Ethernet port.
- 5. Meter to measure and calculate the following information at [one]<Insert value>-second intervals:
 - a. Voltage line-to-neutral and line-to-line for each phase and average of all three phases.
 - b. Percentage of voltage unbalance.
 - c. Current for each phase and average of three phases.
 - d. Percentage of current unbalance.
 - e. kW for each phase and total of three phases.
 - f. kVAR for each phase and total of three phases.

- g. kVA for each phase and total of three phases.
 - h. kWh for total of three phases, provided as accumulating import, export, net, and total readings.
 - i. kVARh for total of three phases, provided as accumulating import, export, net, and total readings.
 - j. kVAh for total of three phases, provided as an accumulating net reading.
 - k. Power factor for each phase and total of three phases.
 - l. Frequency.
 - m. Harmonic distortion for each voltage and current input, provided as individual harmonic magnitudes up to the 15th harmonic and as total odd, total even, and total overall harmonic distortion; readings given as a percentage of fundamental.
 - n. K-factor calculations of the first 15 harmonics for all current inputs.
6. Operator interface features as follows:
- a. Capable of calculating the following information for any reading at [one]<Insert value>-second intervals:
 - 1) Thermal demand calculations for any parameter, with operator-programmable length of demand period to match local utility billing method.
 - 2) Sliding window demands for any parameter with operator-programmable length of demand period and number of subperiods to match local utility billing method.
 - 3) Predicted demand calculations of sliding window demand parameters, with operator-programmable predictive response characteristics.
 - 4) Minimum value for any measured parameter.
 - 5) Maximum value for any measured parameter.
 - 6) Derived values for any combination of measured or calculated parameter, using the following arithmetic, trigonometric, and logic functions (equivalent PLC capabilities):
 - a) Arithmetic functions: division, multiplication, addition, subtraction, power, absolute value, square root, average, max, min, rms, sum, sum-of-squares, unary minus, integer ceiling, integer floor, modulus, exponent, PI.
 - b) Trigonometric Functions: COS, SIN, TAN, ARCCOS, ARCSIN, ARCTAN, LN, and LOG10.
 - c) Logic Functions: Equal to, equal to or more than, equal to or less than, more than or less than, less than, more than, and, "OR," "NOT," and "IF."
 - d) Thermocouple Linearization Functions: Type J, Type K, Type R, Type RTD, or Type T.
 - e) Temperature Conversion Functions: degree C to degree F and degree F to degree C.
 - b. Direct display of all parameters on the front panel or remote display in user-programmable groups, using plain language labels. Make simultaneous access to all parameters available through any communication port.
 - c. Field programmable as follows:
 - 1) Basic Parameters: Voltage input scale, voltage mode (wye, delta, single phase), current input scale, auxiliary input and output scales, and communication setup parameters are to be programmable from the front panel.
 - 2) Additional Parameters: Set-point/relay and data log setup parameters are to be programmable through the communication port using a portable or remotely located computer terminal. Using ION modules, support customized configurations of all operating parameters.
 - 3) Secure programming through a computer by user ID and password.
 - 4) Secure programming at front panel by password.

- d. Provide for creation of periodic or non-periodic schedules for up to **[two]<Insert number>** years. Schedules may be used to perform the following functions:
 - 1) Demand control.
 - 2) Load scheduling.
 - 3) Logging.
 - 4) Periodic resetting.
- 7. Alarming and set-point control to include following minimum requirements:
 - a. Set-point control of internal recording mechanisms and all digital output relays as follows:
 - 1) **[12]<Insert number>** programmable set points, each of which is to respond to out-of-range and alarm conditions for any measured parameter.
 - a) Each set point with **[one]<Insert value>**-second minimum response time.
 - b) Each set point with programmable pick-up and drop-out levels (high and low limits) and time delays on operate and release.
 - c) Activity of each set point to generate an event of a programmable priority and able to support up to **[256]<Insert number>** levels of alarm severity.
 - d) Any set point programmable to any operating condition, and any number of available set points concurrently programmable to operate on a particular condition to support multiple threshold conditions.
 - 2) Set points programmable to operate on any over or under condition for the following:
 - a) Any voltage or current input or average.
 - b) Voltage or current imbalance.
 - c) kW or kVAR forward or reverse.
 - d) kVA.
 - e) Power factor lag or lead.
 - f) Frequency.
 - g) kW or current demand on any phase, total, or average.
 - h) Individual harmonic distortion on any phase input.
 - i) Total harmonic distortion on any phase input.
 - j) Total even or odd harmonic distortion on any phase input.
 - k) Any maximum or minimum value.
 - l) Multiple energy accumulation conditions.
 - m) Phase reversal.
 - n) Pulse count levels.
 - o) Any internally derived value.
 - 3) Any set-point condition able to control any number of digital output relays in an AND or an OR configuration, using pulse mode or latch mode operation, for control and alarm purposes. Digital outputs are operable remotely via any communication port.
 - 4) Any set-point condition to provide breaker trip relay operation.
 - 5) Consecutive alarm conditions and triggers with no "dead" time between events and no need for a rearming delay time between events.
 - 6) Able to use any logical combination of any number of available set-point conditions to control any internal or external function or event.
 - 7) Digital outputs with pulse output relay operation for kWh total, kWh imported, kWh exported, kVARh total, kVARh imported, kVARh exported, and kVAh values.

D. Electric Power Meter - Multifunction:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Allen Bradley; by Rockwell Automation]
 - b. [Eaton]
 - c. [Siemens Industry, Inc., Building Technologies Division]
 - d. [Square D; Schneider Electric USA]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Allen Bradley; by Rockwell Automation]
 - b. [Eaton]
 - c. [Siemens Industry, Inc., Building Technologies Division]
 - d. [Square D; Schneider Electric USA]
 - e. <Insert manufacturer's name>
3. Hardware:
 - a. Voltage Inputs:
 - 1) [Three]<Insert value> voltage inputs capable of measuring from zero to 400 V rms (line to neutral) or from zero to 690 V rms (line to line).
 - 2) Provisions for direct connection for wye (Star) systems up to 347/600 V ac. For higher-voltage systems, use PTs with 120, 277, or 347 V ac secondaries.
 - 3) Voltage inputs with the following:
 - a) 1500 V ac continuous surge protection.
 - b) 25 percent of full-scale voltage over range capability.
 - b. Current Inputs:
 - 1) [Three]<Insert value> 5 A nominal (6 A full-scale) current inputs.
 - 2) Current inputs transformer coupled and accepting CTs with 5 A nominal (6 A full-scale) outputs.
 - 3) Current inputs with the following:
 - a) 120 A surge protection for one second.
 - b) 20 percent of nominal current continuous over range capability.
 - c. Power Supply:
 - 1) Voltage: 100 to 240 V ac (within 10 percent) at 50 to 60 Hz, 110 to 300 V dc, or 20 to 60 V dc power source.
 - 2) Load: Not exceed 15 W.
 - d. Onboard I/O: [Two]<Insert value> Form A solid-state digital (status) outputs with the following features:
 - 1) The ability to be used to provide pulse outputs according to any energy consumption levels.
 - 2) Rated 200 V ac/dc with a maximum current of 100 mA.

- e. Communications:
 - 1) Provide the following built-in communication ports of standard technology, as defined by the IEEE:
 - a) One optically isolated RS-485 communication port, supporting data rates from 1200 to [19,200]<Insert value> bits per second.
 - 2) Communication ports with the following communication capabilities, independently configurable:
 - a) Modbus RTU [and][or][BACnet MS/TP] protocol.
 - b) Simultaneous access through all communication ports to any measured or derived parameter.
 - c) Protocols field configurable from the front display, or via communication ports, and capable of being accomplished without resetting the meter or interrupting its operation in any way.
 - d) Support time synchronization broadcast messages from a host computer system.
 - f. Mounting and Display:
 - 1) Mounting Options:
 - a) Panel cutout, using sliding clamps tightened by thumbscrews.
 - b) Transducer-type base unit with a remote LED display with cable for remote display applications.
 - c) Transducer-type base unit locally mounted.
 - d) Allow the operator to remove and replace the display panel without removing the instrument from the equipment in which it is mounted.
 - g. Enclosure: If installation requires meter to be installed in a dedicated enclosure, install meter in an NRTL-listed enclosure suitable for operating environment at meter location.
 - 1) Indoors: NEMA 250, [Type 1][or][Type 12].
 - 2) Outdoors: NEMA 250, [Type 4][or][Type 4X].
 - h. Memory: Sufficient non-volatile memory to store setup data and accumulated energy values.
4. Meter to measure and calculate the following information:
- a. Voltage line-to-neutral and line-to-line for each phase and average of three phases.
 - b. Current for each phase and average of three phases.
 - c. Peak current demand.
 - d. Neutral current.
 - e. Power (kW).
 - f. Peak power demand (kW).
 - g. Energy (kWh) import/export.
 - h. Power factor total.
 - i. Frequency.
5. Operator interface features as follows:
- a. Display of all parameters on the front panel or remote display using plain language labels with simultaneous access to all parameters through any communication port.

- b. Field programmable or configurable as follows:
 - 1) Basic Parameters: Voltage input scale, voltage mode (wye, delta, single phase), current input scale, auxiliary input and output scales, and communication setup parameters.
 - 2) Security provisions with password protection.
 - 3) Digital outputs with pulse output relay operation for kWh total, kWh imported, kWh exported, kVARh total, kVARh imported, kVARh exported, and kVAh values.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 THERMAL ENERGY METER APPLICATIONS

- A. Thermal Energy Meters with Insertion Impeller Flow Sensor: **<Insert equipment type>, <Insert service>.**
- B. Thermal Energy Meters with Insertion Turbine Flow Sensor: **<Insert equipment type>, <Insert service>.**
- C. Thermal Energy Meters with Insertion Electromagnetic Flow Sensor: **<Insert equipment type>, <Insert service>.**
- D. Thermal Energy Meters with In-Line Electromagnetic Flow Sensor: **<Insert equipment type>, <Insert service>.**
- E. Thermal Energy Meters, Compact Type, with In-Line Ultrasonic Flow Sensor: **<Insert equipment type>, <Insert service>.**
- F. Thermal Energy Meters with Clamp-On Ultrasonic Flow Sensor: **<Insert equipment type>, <Insert service>.**

3.3 ELECTRIC POWER METER APPLICATIONS

- A. Electric Power Meter - Basic: **<Insert equipment type>.**

- B. Electric Power Meter - Multifunction, Fully Programmable: **<Insert equipment type>**.
- C. Electric Power Meter - Multifunction: **<Insert equipment type>**.

3.4 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a **<Insert value>** force.
- C. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- D. Mount meters located in mechanical and electrical rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of **42 to 72 inches (1050 to 1800 mm)**, but preferably at **60 inches (1500 mm)** above the adjacent floor, grade, or service catwalk or platform.

3.5 INSTALLATION OF THERMAL METERS

- A. Install meters not integral to flow sensors in vicinity of flow sensor. Where multiple meters are serving same system and located in same room, co-locate them by system to provide service personnel a single and convenient location for inspection and service.
- B. Install meter flow sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream.
- C. Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.
- D. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on performance.
- E. Install in-line meters with flanges or unions to provide drop-in and -out installation.
- F. Insertion Meters:
 - 1. Install system process connections full size of meter connection, but not less than **[NPS 1 (DN 25)][NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]<Insert pipe size>**. Provide **[stainless steel]** bushing if required to mate to system connection.
 - 2. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
 - 3. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

3.6 INSTALLATION OF POWER METERS

- A. Install meters not integral to flow sensors in vicinity of flow sensor. Where multiple meters are serving same system and located in same room, co-locate them by system to provide service personnel a single and convenient location for inspection and service.

- B. Install meter flow sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream.
- C. Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.
- D. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on performance.
- E. Install in-line meters with flanges or unions to provide drop-in and -out installation.

3.7 ELECTRICAL CONNECTIONS

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.23 "Surface Raceways for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.8 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Furnish and install raceways. Comply with requirements in Section 260533.23 "Surface Raceways for Electrical Systems."

3.9 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire and cable is to have the same designation at each end for operators to determine continuity at points of connection. Comply with

requirements for identification specified in Section 260553 "Identification for Electrical Systems."

- B. Install engraved phenolic nameplate with instrument identification[**and on face of ceiling directly below instruments concealed above ceilings**].

3.10 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.11 CHECKOUT PROCEDURES

- A. Checkout Requirements:
 - 1. Check out installed products before continuity tests, leak tests, and calibration.
 - 2. Check instruments for proper location and accessibility.
 - 3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
 - 4. Verify that sensors are installed correctly with respect to flow direction.
 - 5. Verify that sensor attachment is properly secured and sealed.
 - 6. Inspect meter tags against approved submittal.
 - 7. Verify that recommended upstream and downstream distances have been maintained.

3.12 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. Equipment and procedures used for calibration are to meet instrument manufacturer's written instructions.
 - 4. Provide diagnostic and test equipment for calibration and adjustment.
 - 5. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
 - 6. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
 - 7. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11 in the absence of specific requirements, and to supplement requirements indicated.
- B. Analog Signals:
 - 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 - 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
- C. Digital Signals:
 - 1. Check digital signals using a jumper wire.
 - 2. Check digital signals using an ohmmeter to test for contact.



3.13 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes **[three][six][nine][12]** months' full maintenance by **[skilled employees of systems and equipment Installer][manufacturer's authorized service representative]**. Include **[monthly][quarterly][semiannual][annual]** preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper **<Insert equipment>** operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

3.14 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 09 23 13



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 23 13	23 09 23 00	Direct Digital Control (DDC) System for HVAC
23 09 23 13	23 09 23 00a	Leak Detection Instruments
23 09 23 13	23 09 23 00b	Position Instruments
23 09 23 13	23 09 00 00	Speed Instruments
23 09 23 13	23 09 23 00c	Sequence of Operations for HVAC DDC



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 09 23 14 - FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Airflow-measurement stations and sensors.
2. Airflow switches.
3. Airflow transmitters.
4. Liquid flow meters.
5. Steam flow meters.
6. Liquid flow sensors (primary elements).
7. Steam flow sensors (primary elements).
8. Liquid flow switches.
9. Liquid flow transmitters.
10. Steam flow transmitters.

B. Related Requirements:

1. Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230923.12 "Control Dampers" for control dampers with integrated airflow measurement in a packaged assembly.
3. Section 230993.11 "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.
4. Section 232216 "Steam and Condensate Piping Specialties" for self-contained steam and condensate meters, with options to connection to the DDC system.

1.2 DEFINITIONS

- A. BLE: Bluetooth low energy.
- B. BTL: BACnet testing laboratories.
- C. Ethernet: Local area network based on IEEE 802.3.1.
- D. FEP: Fluorinated ethylene propylene.
- E. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bidirectional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from a technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.
- F. PEEK: Polyetheretherketone.
- G. PTFE: Polytetrafluoroethylene.

- H. PPS: Polyphenylene sulfide.
- I. RS-485: A TIA standard for multipoint communications using two twisted pairs.
- J. RTD: Resistance temperature detector.
- K. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Airflow-measurement stations and sensors.
2. Airflow switches.
3. Airflow transmitters.
4. Liquid flow meters.
5. Steam flow meters.
6. Liquid flow sensors (primary elements).
7. Steam flow sensors (primary elements).
8. Liquid flow switches.
9. Liquid flow transmitters.
10. Steam flow transmitters.

B. Product Data Submittals: For each product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.
5. Product certificates.

C. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

D. Shop Drawings:

1. Include plans, elevations, sections, and[**mounting**] details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

E. Delegated Design Submittals:

1. Schedule and design calculations for flow instruments, including the following:

- a. Flow at Project design and minimum flow conditions.
- b. Pressure drop at Project design and minimum flow conditions.
- c. Show a side-by-side direct comparison to performance characteristics indicated for each instrument.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each product requiring a certificate.
- B. Product Test Reports: For each product, for tests performed by **[manufacturer and witnessed by a qualified testing agency][a qualified testing agency]**.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials[, **from the same production run,**] to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Provide parts, as indicated by manufacturer's recommended parts list, for product operation during **[one][two]<Insert number>**-year period following warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: **[Product manufacturer's qualified staff][Qualified professional engineer employed by the product manufacturer]** to select and size products to achieve specified performance requirements.
- B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

- A. Air sensors and transmitters are to have an extended range of **[10][20]<Insert number>** percent above Project design flow and **[10][20]<Insert number>** percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.
- B. Liquid and steam sensors, meters, and transmitters are to have an extended range of **[10][20]<Insert number>** percent above Project design flow and **[10][20]<Insert number>** percent below Project minimum flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

2.3 AIRFLOW-MEASUREMENT STATIONS AND SENSORS

A. Performance Requirements:

1. Adjustable for changes in system operational parameters.
2. Airflow Sensor and Transmitter Range: Extended range of [10][20]<Insert number> percent above Project design flow and [10][20]<Insert number> percent below minimum Project flow to signal abnormal flow conditions.
3. Manufacturer is to certify that each flow instrument indicated complies with specified performance requirements and characteristics.
 - a. Product certificates are required.

B. Thermal Airflow-Measurement Stations:

1. Certification:
 - a. Listed and labeled in accordance with UL 873 or UL 60730.
 - b. BTL Certified in accordance with ASHRAE 135 where BACnet communication is required.
 - c. Class A device in accordance with 47 CFR, Chapter I - "Federal Communications Commission," Part 15 - "Radio Frequency Devices," Subpart A - "General"; Subpart B - "FAA Notification Criteria."
2. Common Performance Requirements:
 - a. Airflow Accuracy: Comply with following requirements unless otherwise indicated.
 - 1) Individual Airflow Accuracy: Within [2]<Insert number> percent of reading over the entire operating airflow velocity range from [0 to 4000 fpm (0 to 20.3 m/s)][0 to 5000 fpm (0 to 25.4 m/s)]<Insert velocity range>
 - 2) Thermal Airflow Station Assembly Airflow Accuracy: Within [2]<Insert number> percent of reading over the entire operating airflow range from [0 to 4000 fpm (0 to 20.3 m/s)][0 to 5000 fpm (0 to 25.4 m/s)]<Insert velocity range>.
 - a) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.
 - b. Process Air Temperature Accuracy: Within [0.15 deg F (0.08 deg C)]<Insert temperature> over entire operating range of [minus 20 to plus 140 deg F (minus 29 to plus 60 deg C)]<Insert temperature range>.
 - c. Ambient Operating Temperature Range:
 - 1) Sensor: [Minus 20 to plus 160 deg F (Minus 29 to plus 71 deg C)]<Insert temperature range>.
 - 2) Transmitter: [Minus 20 to plus 120 deg F (Minus 29 to plus 49 deg C)]<Insert temperature range>.
 - d. Ambient Operating Humidity Range:
 - 1) Sensor: Zero to [100]<Insert number> percent.
 - 2) Transmitter: Zero to [95]<Insert number> percent, non-condensing.
 - e. Instruments to compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.

- f. Reference Pressure Loss: **[0.05 inch wg (12.5 Pa) at 2000 fpm (10 m/s)]<Insert pressure loss requirements>**.
 - g. Electrical Power: 24 V ac (between 22.8 and 26.4 V ac under load), using a switching power supply that is overcurrent and overvoltage protected.
3. Common Instrument Requirements:
- a. Manufacturer to certify that each flow instrument indicated complies with specified performance requirements and characteristics.
 - b. Provide thermal airflow stations with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location.
 - c. Provide stations that can be adjusted in the field to accommodate changes in system operational parameters.
 - d. Sensor-Node and Probe Assemblies Features and Functions:
 - 1) Number of sensors for each airflow station to be determined by manufacturer for each specific application to comply with accuracy indicated while complying with requirements indicated.
 - 2) Each sensor to contain two individually wired, hermetically sealed thermistors.
 - 3) Sensor Nodes: One self-heated and one zero-power thermistor, using the principle of thermal dispersion.
 - 4) Airflow Rate and Temperature of Each Sensor: Equally weighted and averaged by the transmitter before sending output signal[**unless temperature sensor has an accuracy of 0.10 deg F (0.05 deg C)**].
 - 5) Mount thermistors in sensor using a marine-grade, waterproof material.
 - 6) Protect thermistor leads and internal probe cable and wire from exposure to the ambient environment. Seal and protect so that direct exposure to water will not affect instrument operation.
 - 7) Each sensor assembly to independently determine airflow rate and temperature at each sensor measurement point.
 - 8) Enclosure:
 - a) Indoor Applications: NEMA 250, Type 1, 4, 4X, or 12.
 - b) Outdoor Applications: NEMA 250, Type 4 or 4X.
 - 9) Sensor-Probe Mounting Bracket Construction:
 - a) Aluminum Probes: Aluminum, Type 304 or Type 316 stainless steel mounting brackets.
 - b) Stainless Steel Probes: Type 304 or 316 stainless steel; type of stainless steel to match probe material.
 - 10) Sensor-Node Construction: Two, bead-in-glass, hermetically sealed thermistors potted in a marine-grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Construct with only the thermistor located within the sensing node and all other electronic components outside the airstream.
 - 11) Store sensor-node airflow and temperature calibration data in a serial memory chip, in the cable-connecting plug. Stored data does not require matching or adjustments to the transmitter in the field.
 - 12) Performance rate and test with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory results.
 - 13) **<Insert requirements>**.
 - e. Transmitter Features and Functions:
 - 1) Microprocessor based.

- 2) Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
 - 3) Capable of field configuration and diagnostics using an onboard push-button interface and digital display.
 - 4) Password-protected programmable settings.
 - 5) Field selectable between IP and SI units for airflow, temperature, and velocity.
 - 6) Include an integral power switch to operate on 24 V ac (isolation optional) and include the following:
 - a) Integral protection from transients and power surges.
 - b) Circuitry to ensure reset after power disruption, transients, and brownouts.
 - c) Integral transformer to convert field power source to operating voltage required by instrument.
 - 7) Enclosure:
 - a) Indoor Applications: NEMA 250, Type 1, 4, 4X, or 12.
 - b) Outdoor Applications: NEMA 250, Type 4 or 4X.
 - 8) Remote Signal Interface Options: Specific interface options are listed for each application.
 - a) Linear Analog Signals for Airflow and Temperature: Fuse protected and isolated, field selectable, zero to 10 V dc or 4 to 20 mA.
 - b) RS-485: BACnet-MS/TP, Modbus RTU.
 - c) Ethernet: BACnet Ethernet, BACnet-IP, Modbus TCP/IP.
 - 9) If quantity of sensors required by a single airflow station assembly exceeds capability of a single transmitter, provide multiple transmitters and associated software programming needed to support them operating as a single airflow station assembly through one transmitter that is remotely mounted and easily accessible from the floor.
 - 10) High- and/or low-airflow alarm with user-defined set point and percentage of set-point tolerance.
 - 11) Manual or automatic alarm reset, and low-limit cutoff value may be selected to disable the alarm.
 - 12) Alarm delay function, field defined.
 - 13) Sensor-node malfunction via the system status alarm. Ignore the sensor node that is in a fault condition.
 - 14) Field configuration, diagnostics, and field output adjustment wizard that allow for a one- or two-point field adjustment to factory calibration for installations that require adjustment.
 - 15) Automatic reset after power disruption, transients, and brownouts.
 - 16) Integration Buffers: Separate integration buffers for display of airflow output, airflow signal output (analog and network), and individual sensor output (IR-interface).
 - 17) **<Insert requirements>**.
4. Electrical Power and Control Signal Cable and Raceways:
- a. Indoor Applications: Only where exposed cable is allowed by installation requirements, interconnect components using exposed NRTL-listed plenum-rated cable complying with manufacturer's requirements; otherwise install cable in continuous conduit.
 - b. Outdoor Applications: Fit instruments and devices with conduit connections for mating to field-installed conduit. Do not exposed wire and cable at any point.

5. Duct/Plenum Thermal Airflow-Measurement Station:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **[Ebtron, Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **[Ebtron, Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain all duct/plenum airflow-measurement stations from a single manufacturer.
 - d. Application: Duct/plenum sizes greater than **2 sq. ft. (0.18 sq. m)**.
 - e. Airflow Station Performance:
 - 1) Independent processing of up to **[16]<Insert number>** separately wired sensor-node assemblies.
 - 2) Accuracy within **[3]<Insert number>** percent of reading for ducted applications, and within **[5]<Insert number>** percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines.
 - a) Include the combined uncertainty of the sensor nodes and transmitter.
 - b) For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with accuracy requirement over entire operating range.
 - f. Airflow Station Casing:
 - 1) Application: Factory install probes and sensor assemblies into an airflow station casing in lieu of field installing individual probes and sensors in ducts and plenums.
 - 2) Casing Configuration and Size: Match shape (rectangular, round, flat oval) and same size as adjacent duct unless otherwise indicated.
 - 3) Casing Depth: Minimum **8 inches (200 mm)**.
 - 4) Casing Flanges: Outward flange, minimum flange face **1.5 inches (38 mm)**.
 - 5) Joints and Seams: Continuously weld joints and seams. Clean galvanized areas damaged by welding and coat with galvanize paint.
 - 6) Materials:
 - a) Aluminum, minimum **0.063 inch (1.6 mm)** thick, when connected to aluminum duct.
 - b) Galvanized steel, minimum **0.079 inch (2.0 mm)** thick with coating complying with ASTM A653/A653M, **G90 (Z275)**, when connected to galvanized steel duct.
 - c) Stainless steel, minimum **0.0781 inch (2.0 mm)** thick, when connected to stainless duct. Stainless steel, Type 304 or 316, to match adjoining duct.

- 7) Flow Straightener: Include each airflow station casing with an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to casing.
 - a) Individual Cell Size: **0.5 inches (13 mm)** wide across entering face, **3 inches (75 mm)** deep in direction of airflow, **0.002 inch (0.051 mm)** thick
 - b) Construct from Type 3003 aluminum for aluminum and galvanized steel casings.
 - c) Construct from Type 316 stainless steel for units for stainless steel casings.
- g. Sensor-Node and Probe Assemblies:
 - 1) Sensor-Node Calibration:
 - a) Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
 - b) Individually calibrated [**at a minimum of 16 calibration points**]<Insert **calibration points**> to NIST-traceable volumetric standards.
 - c) Accuracy within [**2**]<Insert **number**> percent of reading over the entire calibrated airflow range of [**0 to 5000 fpm (0 to 25.4 m/s)**]<Insert **velocity range**>.
 - d) Individually calibrate thermistors [**at a minimum of three temperatures**]<Insert **calibration requirements**> to NIST-traceable temperature standards.
 - 2) Minimum number of independent sensor nodes for duct/plenum areas as follows:
 - a) Provide [**six**]<Insert **number**> for area greater than **2.0 through 4.0 sq. ft. (0.186 through 0.372 sq. m)**.
 - b) Provide [**eight**]<Insert **number**> for area greater than **4.0 through 8.0 sq. ft. (0.372 through 0.743 sq. m)**.
 - c) Provide [**12**]<Insert **number**> for area greater than **8.0 through 12.0 sq. ft. (0.743 through 1.11 sq. m)**.
 - d) Provide [**14**]<Insert **number**> for area greater than **12.0 through 14.0 sq. ft. (1.11 through 1.30 sq. m)**.
 - e) Provide [**16**]<Insert **number**> for area greater than **14.0 sq. ft. (1.30 sq. m)**.
 - 3) For an aspect ratio of 1.5 or less, and an area of **25 sq. ft. (2.32 sq. m)** or greater, provide at least four probes.
 - 4) Sensor-Probe Construction: [**Anodized, 6063 aluminum alloy tube**][or][**Type 316 stainless steel tube**], with each sensor probe containing one or more independently wired sensing nodes.
- h. Transmitter:
 - 1) Transmitter determines average airflow rate and temperature of connected sensor nodes in an array for a single location.
 - 2) Operator Interface: Backlit, alphanumeric [**(16-character)**]LCD display with following remote interface capability:
 - a) Transmitter with Analog Outputs: Two field-selectable [**zero to 5 V dc,**][**zero to 10 V dc,**][or][**4 to 20 mA,**] scalable, isolated, and overcurrent-protected analog output signals. First output provides total airflow rate. Second output field is configurable for temperature, low- and/or high-airflow set-point (user-defined) alarm, or system status alarm.

- b) Transmitter with RS-485 Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides average airflow rate, temperature, high- and/or low-airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.
- c) Transmitter with Analog Outputs, RS-485 Network Communication, and Bluetooth Capability: Two field-selectable [**zero to 5 V dc,**][**zero to 10 V dc,**][**or**][**4 to 20 mA,**] scalable, isolated, overcurrent-protected analog output signals and network output capability. First output provides total airflow rate. Second output is field configurable for temperature, low- and/or high-airflow set-point (user-defined) alarm, or system status alarm. RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides average airflow rate, temperature, high- and/or low-airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. Provide transmitter with Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Include Bluetooth software is capable of capturing and displaying this transmission via download to Android or iOS phone or tablet. Bluetooth software provides setup parameters and airflow, temperature, and diagnostic data to be saved on the phone or tablet, or emailed.
- d) Transmitter with Analog Outputs, IP Network Communication, and Bluetooth Capability: Two field-selectable [**zero to 5 V dc,**][**zero to 10 V dc,**][**or**][**4 to 20 mA,**] scalable, isolated, and overcurrent-protected analog output signals and network output capability. First output provides the total airflow rate. Second output is field configurable for temperature, low- and/or high-airflow set-point (user-defined) alarm, or system status alarm. Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides average airflow rate, temperature, high- and/or low-airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. Provide transmitter with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Include Bluetooth software is capable of capturing and displaying this transmission via download to Android or iOS phone or tablet. Bluetooth software provides setup parameters and airflow, temperature, and diagnostic data to be saved on the phone or tablet, or emailed.
- e) Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.
- f) Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

6. Small Duct/Plenum Thermal Airflow-Measurement Stations:

- a. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - 1) [**Air Monitor; an ONICON Brand**]
 - 2) [**Ebtron, Inc**]
 - 3) [**Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.**]
 - 4) [**<Insert manufacturer's name>**]
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- 1) **[Air Monitor; an ONICON Brand]**
 - 2) **[Ebtron, Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain all small duct/plenum thermal airflow-measurement stations from a single manufacturer.
- d. Application: Small duct/plenum size of **2 sq. ft. (0.18 sq. m)** or less.
- e. Airflow Station Performance:
- 1) Independent processing of up to four separately wired sensor-node assemblies.
 - 2) Accuracy within **[3]<Insert number>** percent of reading for ducted applications, and within **[5]<Insert number>** percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines.
 - a) Include the combined uncertainty of the sensor nodes and transmitter.
 - b) For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with accuracy requirement over entire operating range.
- f. Sensor-Node and Probe Assemblies:
- 1) Sensor-Node Calibration:
 - a) Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
 - b) Individually calibrated **[at a minimum of 16 calibration points]<Insert calibration points>** to NIST-traceable volumetric standards.
 - c) Accuracy within **[2]<Insert number>** percent of reading over the entire calibrated airflow range of **[0 to 5000 fpm (0 to 25.4 m/s)]<Insert velocity range>**.
 - d) Individually calibrate thermistors **[at a minimum of three temperatures]<Insert calibration requirements>** to NIST-traceable temperature standards.
 - 2) Minimum number of independent sensor nodes for duct/plenums as follows:
 - a) Provide **[one]<Insert number>** for area up to **0.5 sq. ft. (0.046 sq. m)**.
 - b) Provide **[two]<Insert number>** for area greater than **0.5 through 1.0 sq. ft. (0.046 through 0.092 sq. m)**.
 - c) Provide four for area greater than **1.0 sq. ft. (0.092 sq. m)**.
 - 3) For probes less than **8 inches (203 mm)**, provide one sensor node/probe.
 - 4) Sensor-Probe Construction: **[Anodized, 6063 aluminum alloy tube][or][Type 316 stainless steel tube]**, with each sensor probe containing one or more independently wired sensing nodes.
- g. Transmitter:
- 1) Transmitter determines average airflow rate and temperature of connected sensor nodes in an array for a single location.

- h. Operator Interface: Backlit, alphanumeric, LCD display with following remote interface:
 - 1) Transmitter with Analog Outputs: Two field-selectable **[zero to 5 V dc],[1 to 5 V dc],[zero to 10 V dc],[or][2 to 10 V dc]**, scalable analog output signals. First output provides total airflow rate. Second output is field configurable for temperature, low-and/or high-airflow set-point (user-defined) alarm, or system status alarm.
 - 2) Transmitter with RS-485 Network Communications: RS-485 (BACnet MS/TP or Modbus RTU) network connection provides average airflow rate, temperature, high-and/or low-airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.
- 7. Fan Array Thermal Airflow-Measurement Stations:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **[Ebtron, Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **[Ebtron, Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain all fan array thermal airflow-measurement stations from a single manufacturer.
 - d. Airflow Station Performance:
 - 1) Independent processing of up to eight separately wired sensor-node assemblies.
 - 2) Accuracy within **[10]<Insert number>** percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance.
 - a) Include the combined uncertainty of the sensor nodes and transmitter.
 - b) For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with accuracy requirement over entire operating range.
 - 3) Airflow Station Impact on Fan Performance: Sensor assemblies mounted in throat or face of fan inlet are not to negatively influence fan performance by reducing airflow more than **[1]<Insert number>** percent of Project design flow or negatively impact fan-generated sound. Document performance impact with submittal data, and make necessary adjustments to compensate for performance impact to fan in order to deliver not less than Project design airflow indicated.
 - e. Sensor-Node and Probe Assemblies:
 - 1) Sensor-Node Calibration:

- a) Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
 - b) Individually calibrated [**at a minimum of 16 calibration points**]<Insert **calibration points**> to NIST-traceable volumetric standards.
 - c) Accuracy within [**2**]<Insert **number**> percent of reading over the entire calibrated airflow range of [**0 to 10,000 fpm (0 to 50.8 m/s)**]<Insert **velocity range**>.
 - d) Individually calibrate thermistors [**at a minimum of three temperatures**]<Insert **calibration requirements**> to NIST-traceable temperature standards.
- 2) Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.
 - 3) Number of Independent Sensor Nodes, Fan Arrays: For one to [**8**]<Insert **number**> fans, one probe with one sensor node per probe in each fan inlet.
- f. Transmitter:
- 1) Transmitter determines average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.
 - 2) Operator Interface: Backlit, alphanumeric [**(16-character)**]LCD display with following remote interface capability:
 - a) Transmitter with Analog Outputs: Two field-selectable [**zero to 5 V dc,**][**zero to 10 V dc,**][**or**][**4 to 20 mA,**] scalable, isolated, and overcurrent-protected analog output signals. First output provides total airflow rate. Second output is field configurable for temperature, low- and/or high-airflow set-point (user-defined) alarm, or system status alarm.
 - b) Transmitter with RS-485 Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides average airflow rate, temperature, high- and/or low-airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.
 - c) Transmitter with Analog Outputs, RS-485 Network Communication, and Bluetooth Capability: Two field-selectable [**zero to 5 V dc,**][**zero to 10 V dc,**][**or**][**4 to 20 mA,**] scalable, isolated, overcurrent-protected analog output signals and network output capability. First output provides total airflow rate. Second output is to be field configurable for temperature, low- and/or high-airflow set-point (user-defined) alarm, or system status alarm. RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides average airflow rate, temperature, high- and/or low-airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. Provide transmitter with Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Include Bluetooth software is capable of capturing and displaying this transmission via download to Android or iOS phone or tablet. Bluetooth software provides setup parameters and airflow, temperature, and diagnostic data to be saved on the phone or tablet, or emailed.
 - d) Transmitter with Analog Outputs, IP Network Communication, and Bluetooth Capability: Two field-selectable [**zero to 5 V dc,**][**zero to 10 V dc,**][**or**][**4 to 20 mA,**] scalable, isolated, and overcurrent-protected analog output signals and network output capability. First output provides the total airflow rate. Second

output is field configurable for temperature or low- and/or high-airflow set-point (user-defined) alarm, or system status alarm. Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides average airflow rate, temperature, high- and/or low-airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. Provide transmitter with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Include Bluetooth software is capable of capturing and displaying this transmission via download to Android or iOS phone or tablet. Bluetooth software provides setup parameters and airflow, temperature, and diagnostic data to be saved on the phone or tablet, or emailed.

- e) Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across network.
- f) Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

8. Single-Width Single-Inlet (SWSI) and Double-Width Double-Inlet (DWDI) Centrifugal Fan Thermal Airflow-Measurement Stations:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- 1) **[Air Monitor; an ONICON Brand]**
- 2) **[Ebtron, Inc]**
- 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
- 4) **<Insert manufacturer's name>**

- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) **[Air Monitor; an ONICON Brand]**
- 2) **[Ebtron, Inc]**
- 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
- 4) **<Insert manufacturer's name>**

- c. Source Limitations: Obtain all SWSI and DWDI centrifugal fan thermal airflow-measurement stations from a single manufacturer.

- d. Airflow Station Performance:

- 1) Independent processing of **[up to eight]** separately wired sensor-node assemblies.
- 2) Accuracy within **[10]<Insert number>** percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance.
 - a) Include the combined uncertainty of the sensor nodes and transmitter.
 - b) For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with accuracy requirement over entire operating range.

- 3) Airflow Station Impact on Fan Performance: Sensor assemblies mounted in throat or face of fan inlet are not to negatively influence fan performance by reducing airflow

more than [1]<Insert number> percent of Project design flow or negatively impact fan-generated sound. Document performance impact with submittal data, and make necessary adjustments to compensate for performance impact to fan in order to deliver not less than Project design airflow indicated.

e. Sensor-Node and Probe Assemblies:

1) Sensor-Node Calibration:

- a) Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
- b) Individually calibrated [at a minimum of 16 calibration points]<Insert calibration points> to NIST-traceable volumetric standards.
- c) Accuracy within [2]<Insert number> percent of reading over the entire calibrated airflow range of [0 to 10,000 fpm (0 to 50.8 m/s)]<Insert velocity range>.
- d) Individually calibrate thermistors [at a minimum of three temperatures]<Insert calibration requirements> to NIST-traceable temperature standards.

- 2) Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.

- 3) Number of Independent Sensor Nodes: Two probes with one sensor node per probe in each fan inlet.

f. Transmitter:

- 1) Transmitter determines average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.
- 2) Operator Interface: Backlit, alphanumeric [(minimum 16-character)]LCD display with following remote interface capability:
 - a) Transmitter with Analog Outputs: Two field-selectable [zero to 5 V dc],[zero to 10 V dc],[or][4 to 20 mA,] scalable, isolated, and overcurrent-protected analog output signals. First output provides total airflow rate. Second output is field configurable for temperature, low- and/or high-airflow set-point (user-defined) alarm, or system status alarm.
 - b) Transmitter with RS-485 Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides average airflow rate, temperature, high- and/or low-airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.
 - c) Transmitter with Analog Outputs, RS-485 Network Communication, and Bluetooth Capability: Two field-selectable [zero to 5 V dc],[zero to 10 V dc],[or][4 to 20 mA,] scalable, isolated, overcurrent-protected analog output signals and network output capability. First output provides total airflow rate. Second output is field configurable for temperature or low- and/or high-airflow set-point (user-defined) alarm, or system status alarm. RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides average airflow rate, temperature, high- and/or low-airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. Provide transmitter with Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average

airflow, and temperature of the device and the airflow and temperature of each sensor node. Include Bluetooth software is capable of capturing and displaying this transmission via download to Android or iOS phone or tablet. Bluetooth software provides setup parameters and airflow, temperature, and diagnostic data to be saved on the phone or tablet, or emailed.

- d) Transmitter with Analog Outputs, IP Network Communication, and Bluetooth Capability: Two field-selectable **[zero to 5 V dc,][zero to 10 V dc,][or][4 to 20 mA,]** scalable, isolated, and overcurrent protected analog output signals and network output capability. First output provides the total airflow rate. Second output is field configurable for temperature or low- and/or high-airflow set-point (user-defined) alarm, or system status alarm. Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides average airflow rate, temperature, high- and/or low-airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. Provide transmitter with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Include Bluetooth software capable of capturing and displaying this transmission via download to Android or iOS phone or tablet. Bluetooth software provides setup parameters and airflow, temperature, and diagnostic data to be saved on the phone or tablet, or emailed.
- e) Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.
- f) Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

9. Air Terminal Unit Thermal Airflow-Measurement Stations:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **[Ebtron, Inc]**
 - 3) **[ONICON Incorporated]**
 - 4) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 5) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **[Ebtron, Inc]**
 - 3) **[ONICON Incorporated]**
 - 4) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 5) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain all air terminal unit thermal airflow-measurement stations from a single manufacturer.
- d. Airflow Performance:
 - 1) Independent processing of up to **[two]<Insert number>** separately wired sensor-

- node assemblies.
- 2) Accuracy within [3]<Insert number> percent of reading when installed in accordance with manufacturer's recommended placement guidelines.
 - a) Include the combined uncertainty of the sensor nodes and transmitter.
 - b) For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with accuracy requirement over entire operating range.
- e. Sensor-Node and Probe Assemblies:
 - 1) Sensor-Node Calibration:
 - a) Individually calibrated [at a minimum of seven calibration points]<Insert calibration points> to NIST-traceable volumetric standards from [0 to 3000 fpm (0 to 15.2 m/s)]<Insert velocity range>.
 - b) Individually calibrate thermistors [at a minimum of three temperatures]<Insert calibration requirements> to NIST-traceable temperature standards.
 - f. Minimum number of independent sensor nodes as follows:
 - 1) Provide one for duct or terminal unit diameter of 4 inches (102 mm).
 - 2) Provide [two]<Insert number> for duct or terminal diameters 5 through 16 inches (127 through 406 mm).
 - g. Sensor-Probe Construction: [Anodized or mill-finish, 6063 aluminum alloy tube][or][Type 316 stainless steel tube], with each sensor probe containing one or more independently wired sensing nodes.
 - h. Transmitter:
 - 1) Transmitter determines average airflow rate and temperature of all connected sensor nodes in an array for a single location.
 - 2) Operator Interface: Backlit, alphanumeric, LCD display with following remote interface:
 - 3) Transmitter with Analog Outputs: Two field-selectable [zero 5 V dc,][1 to 5 V dc,][zero to 10 V dc,][or][2 to 10 V dc,] scalable analog output signals. First output provides total airflow rate. Second output is field configurable for temperature, low-and/or high-airflow set-point (user-defined) alarm, or system status alarm.
 - 4) Transmitter with RS-485 Network Communications: RS-485 (BACnet MS/TP or Modbus RTU) network connection provides average airflow rate, temperature, high-and/or low-airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.
 - 5) Contact Closure Relay: One dry contact relay with onboard jumper drives a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. Actuator is to be configurable as normally open or normally closed during setup.
- 10. Packaged HVAC Unit Thermal Airflow-Measurement Stations:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Ebtron, Inc]

- 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Ebtron, Inc]**
 - 2) **<Insert manufacturer's name>**
- c. Application: HVAC units, **12.5 tons (44.0 kW)** or smaller, such as **[fan coil units][packaged rooftop units][unit ventilators][and]<Insert equipment types>**.
- d. Airflow Performance:
 - 1) Independent processing of up to two separately wired sensor-node assemblies.
 - 2) Accuracy within 10 percent of reading when installed in accordance with manufacturer's recommended placement guidelines.
 - a) Include the combined uncertainty of the sensor nodes and transmitter.
 - b) For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with accuracy requirement over entire operating range.
- e. Sensor-Node and Probe Assemblies:
 - 1) Sensor-Node Internal Wiring Connections: Sealed and protected from elements and suitable for direct exposure to water. Devices with exposed leads are unacceptable.
 - 2) Sensor-Node Calibration:
 - a) Individually calibrated at a minimum of seven calibration points to NIST-traceable airflow standards from **0 to 3000 fpm (0 to 15.2 m/s)**.
 - b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
 - 3) Minimum number of independent sensor nodes as follows:
 - a) Provide one for diameter of **4 inches (102 mm)**.
 - b) Provide two for diameters **5 through 16 inches (127 through 406 mm)**.
 - 4) Sensor-Probe Construction: Mill-finish, 6063 aluminum alloy tube, with each sensor probe containing one or more independently wired sensing nodes.
- f. Transmitter:
 - 1) Transmitter determines average airflow rate and temperature of all connected sensor nodes in an array for a single location.
 - 2) User Interface: An alphanumeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.
 - 3) Transmitter with Analog Outputs: Two field-selectable **[zero to 5 V dc,][1 to 5 Vdc,][zero to 10 V dc,][or][2 to 10 V dc,]** scalable analog output signals. The first output provides total airflow rate. The second output is field configurable for temperature, low- and/or high-airflow set-point (user-defined) alarm, or system status alarm.
 - 4) Transmitter with RS-485 Network Communications: RS-485 (BACnet MS/TP or Modbus RTU) network connection provides average airflow rate, temperature, high-and/or low-airflow set-point alarm, system status alarm, individual sensor-node

- airflow rates, and individual sensor-node temperatures.
- 5) Contact Closure Relay: One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. Actuator is to be configurable as normally open or normally closed during setup.
11. Data Center Server Rack Thermal Airflow/Pressure- and Temperature-Monitoring Applications:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Ebtron, Inc]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Ebtron, Inc]**
 - 2) **<Insert manufacturer's name>**
 - c. Bidirectional airflow measurement station with temperature output and integral airflow alarming to determine exfiltration or infiltration airflow rate, and its direction and temperature at each measurement location.
 - d. Bidirectional airflow, or equivalent differential pressure data, is provided to the **[Building Automation System (BAS)][DDC System]<Insert control system>**, with system status indication, configurable airflow alarm, and internal diagnostics routines.
 - e. Sensor-Node and Probe Assemblies:
 - 1) Sensor-Node Internal Wiring Connections: Sealed and protected from elements and suitable for direct exposure to water. Devices with exposed leads are unacceptable.
 - 2) Sensor-Node Calibration:
 - a) Individually calibrated at a minimum of nine calibration points to NIST-traceable volumetric standards from **minus 2000 to plus 2000 fpm (minus 10.2 to plus 10.2 m/s)**.
 - b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
 - f. Probe to Transmitter Cables: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from **minus 67 to plus 392 deg F (minus 55 to plus 200 deg C)**, and UV tolerant, with terminal plug for connection to the remotely mounted transmitter.
 - g. Transmitter:
 - 1) Integral Transmitter with Display: Mounted internally to the rack enclosure, an integral, minimum 16-character LCD display capable of simultaneously displaying airflow and temperature, and capable of displaying individual airflow and temperature readings.
 - 2) Transmitter Interface: Four-button interface for field configuration and diagnostics.
 - 3) Power Supply: On-off power switch, 110 V ac at 8 VA, fused and protected from overvoltage, overcurrent, and power surges. Provide dual independent and redundant power supplies.
 - 4) Network Interface: One isolated Ethernet network connection (simultaneously

supporting field-selectable BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP protocols).

C. Velocity Pressure Pitot-Tube Airflow Sensor Stations for Duct Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **<Insert manufacturer's name>**
3. Description: Position multiple total- and static-pressure sensors at the center of equal area of the station cross section and interconnect by respective averaging manifolds. Use Log-Tchebycheff rule for traverse pattern for rectangular stations and equal area for circular and flat oval stations.
 - a. For stations **[4 sq. ft. (0.4 sq. m)]<Insert area>** and smaller, use a minimum of **[one]<Insert number>** total-pressure sensor(s) and **[one]<Insert number>** static-pressure sensor(s) for every **[16 sq. in. (103 sq. cm)]<Insert area>** of station area.
 - b. For stations larger than **[4 sq. ft. (0.4 sq. m)]<Insert area>**, use a minimum of **[one]<Insert number>** total-pressure sensor(s) and **[one]<Insert number>** static-pressure sensor(s) for every **[36 sq. in. (232 sq. cm)]<Insert area>** of station area.
4. Certification: Rate and test performance in accordance with AMCA 610. **[Factory apply AMCA seal to each station.]**
5. Performance:
 - a. Flow Accuracy: Within **[2]<Insert number>** percent of actual airflow.
 - b. Flow Velocity Range: **[400 to 4000 fpm (2.0 to 20.3 m/s)]<Insert flow velocity range>**.
 - c. Pressure Rating: Suitable for maximum system pressure[; **but not less than 8 inches wg (2000 Pa)**].
 - d. Pressure Loss: **[0.015 inch wg (3.8 Pa) at 1000 fpm (5 m/s), or 0.085 inch wg (22.5 Pa) at 2000 fpm (1 m/s)]<Insert pressure loss requirements>**.
 - e. Self-Generated Sound: NC 40; sound level within duct not amplified.
 - f. Temperature Range: **[Minus 20 to plus 200 deg F (Minus 19 to plus 93 deg C)]<Insert temperature range>**.
6. Casing:
 - a. Casing Configuration and Size: Match shape (rectangular, round, flat oval) and same size as adjacent duct unless otherwise indicated.
 - b. Casing Depth: At least **8 inches (203 mm)**.
 - c. Casing Flanges: Outward flange, minimum flange face **1.5 inches (38 mm)**.
 - d. Joints and Seams: Continuously weld joints and seams. Clean galvanized areas damaged by welding and coat with galvanize paint.
 - e. Materials:
 - 1) Aluminum, minimum **0.063 inch (1.6 mm)** thick, when connected to aluminum duct.

-
- 2) Galvanized steel, minimum **0.079 inch (2.0 mm)** thick with coating complying with ASTM A653/A653M, **G90 (Z275)**, when connected to galvanized-steel duct.
 - 3) Stainless steel, minimum **0.0781 inch (2.0 mm)** thick, when connected to stainless steel duct. Use Type 304 or 316 stainless steel to match adjoining duct.
 7. Flow Straightener: Include each airflow station with an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to casing.
 - a. Individual Cell Size: **0.5 inches (13 mm)** wide across entering face, **3 inches (75 mm)** deep in direction of airflow, **0.002 inch (0.051 mm)** thick.
 - b. Construct from Type 3003 aluminum for aluminum and galvanized-steel casings.
 - c. Construct from Type 316 stainless steel for units for stainless steel casings.
 8. Pitot-Tube Array: Construct pressure-sensor array from hard-drawn aluminum, copper, or stainless steel tubing, depending on casing material.
 - a. For aluminum casings, use aluminum[, **copper or stainless steel**] tubing.
 - b. For galvanized-steel casings, use copper or stainless steel tubing.
 - c. For stainless steel casings, use stainless steel tubing.
 - d. Copper Tubing: ASTM B75/B75M and ASTM B280; hard drawn with minimum tube wall thickness of **0.030 inch (0.8 mm)**.
 - e. Stainless Steel Tubing: Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale with minimum wall thickness of **0.035 inch (0.9 mm)**.
 - 1) Chemical and physical properties in accordance with ASTM A269/A269M.
 - f. Internal Piping: Include internal piping to interconnect pitot-tube array and extend to external pressure signal ports.
 - g. External Pressure Signal Ports: Locate on exterior of casing and properly label each port: "Total (high)" and "Static (low)." Terminate each port with [**1/4-inch (6-mm)**] **<Insert size>** metal compression fittings for field connection to tubing.
 9. Identification: Permanent identification label on each station casing indicating model number, size, area, and application-specific airflow range.
 10. Flow Signal: Mate the station pressure signal ports in the field to airflow transmitters [**with 0.10 accuracy and auto-zero feature**][**with 0.25 accuracy and auto-zero feature**]**<Insert airflow transmitter type>** for airflow measurement.
- D. Velocity Pressure Probe-Type Airflow Sensor Stations for Duct Airflow Measurement Stations:
1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. [**Air Monitor; an ONICON Brand**]
 - b. [**Paragon Controls Incorporated**]
 - c. [**Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.**]
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Air Monitor; an ONICON Brand]
 - b. [Paragon Controls Incorporated]
 - c. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain all velocity pressure probe-type airflow sensor stations for duct airflow measurement stations from a single manufacturer.
4. Description:
 - a. Airflow stations utilizing one or more airflow traverse probe(s), factory mounted in a rigid welded casing, to sense and average separate total and static pressure traverses of the airstream.
 - b. Multiple sets of total and static pressure sensing points, positioned along the length of each probe on an equal area basis, traverse the airstream and average the sensed pressures in separate internal manifolds.
 - c. Factory install static and total pressure signal tubing connecting the individual probes together and terminate at the exterior of the casing for field connection.
5. Certification: Rate and test performance in accordance with AMCA 610.[**Factory apply AMCA seal to each station.**]
6. Performance:
 - a. Flow Accuracy: Within [2]<Insert number> percent of actual airflow.
 - b. Flow Velocity Range: [400 to 4000 fpm (2.0 to 20.3 m/s)][100 to 10,000 fpm (0.51 to 50.8 m/s)]<Insert flow velocity range>.
 - c. Pressure Rating: Suitable for maximum system pressure[; **but not less than 8 inches wg (2000 Pa)**]<Insert pressure>.
 - d. Pressure Loss: [0.025 inch wg (6.3 Pa) at 2000 fpm (10 m/s), or 0.085 inch wg (22.5 Pa) at 4000 fpm (20 m/s)]<Insert pressure loss requirements>.
 - e. Self-Generated Sound: NC 40; sound level within the duct not amplified.
 - f. Temperature Range: [Minus 20 to plus 200 deg F (Minus 19 to plus 93 deg C)]<Insert temperature range>.
7. Casing:
 - a. Casing Configuration and Size: Match shape (rectangular, round, flat oval) and same size as adjacent duct unless otherwise indicated.
 - b. Casing Depth: Minimum **8 inches (200 mm)**.
 - c. Casing Flanges: Outward flange, minimum flange face **1.5 inches (38 mm)**.
 - d. Joints and Seams: Continuously weld joints and seams. Clean galvanized areas damaged by welding and coat with galvanize paint.
 - e. Materials:
 - 1) Aluminum, minimum **0.063 inch (1.6 mm)** thick, when connected to aluminum duct.
 - 2) Galvanized steel, minimum **0.079 inch (2.0 mm)** thick with coating complying with ASTM A653/A653M, **G90 (Z275)**, when connected to galvanized-steel duct.
 - 3) Stainless steel, minimum **0.0781 inch (2.0 mm)** thick, when connected to stainless steel duct. Use Type 304 or 316 stainless steel to match adjoining duct.
8. Flow Straightener: Include each airflow station with an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to casing.
 - a. Individual Cell Size: **0.5 inches (13 mm)** wide across entering face, **3 inches (75 mm)** deep in direction of airflow, **0.002 inch (0.051 mm)** thick.
 - b. Construct from Type 3003 aluminum for aluminum and galvanized-steel casings.
 - c. Construct from Type 316 stainless steel for units for stainless steel casings.

9. Airflow Probe Array: Construct station array using anodized extruded-aluminum probe(s) or stainless steel probe(s), depending on casing material. Each airflow traverse probe mounted within the station contains multiple total and static pressure sensors located along its exterior surface, and internally connected to their respective averaging manifolds. The flow sensors are not to protrude beyond the surface of the probe(s). Locate total and static pressure sensors at the centers of equal areas for rectangular stations and at equal concentric area centers (for circular ducts) across the station's face area.
 - a. For aluminum casings, use anodized extruded-aluminum probes.
 - b. For galvanized-steel casings, use anodized extruded-aluminum probes.
 - c. For stainless steel casings, use Type 316 stainless steel probes.
 - d. Copper Tubing: ASTM B75/B75M and ASTM B280; hard drawn with minimum tube wall thickness of **0.030 inch (0.8 mm)**.
 - e. Stainless Steel Tubing: Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale with minimum wall thickness of **0.035 inch (0.9 mm)**.
 - 1) Chemical and physical properties in accordance with ASTM A269/A269M.
 - f. Internal Piping: Include internal piping to interconnect individual probes and extend to external pressure signal ports. Use copper tubing to interconnect aluminum probes, and use stainless steel tubing to interconnect stainless steel probes.
 - g. External Pressure Signal Ports: Locate on exterior of casing and properly label each port: "Total (high)" and "Static (low)." Terminate each port with **[1/4-inch (6-mm)] <Insert size>** metal compression fittings for field connection to tubing.
10. Identification: Permanent identification label on each station casing indicating model number, size, area, and application-specific airflow range.
11. Flow Signal: Mate the stations' pressure signal ports in the field to airflow transmitters **[with 0.10 accuracy and auto-zero feature][with 0.25 accuracy and auto-zero feature]<Insert airflow transmitter type>** for airflow measurement.

E. Velocity Pressure Probe-Type Airflow Sensors for Duct Airflow Measurement Stations:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[Paragon Controls Incorporated]**
 - c. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[Paragon Controls Incorporated]**
 - c. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all velocity pressure probe-type airflow sensors for duct airflow-measurement stations from a single manufacturer.

4. Description:
 - a. One or more airflow traverse probe(s), for individual field installation in ducts, to sense and average separate total and static pressure traverses of airstream.
 - b. Multiple sets of total and static pressure sensing points, positioned along length of each probe on an equal area basis, traverse the airstream and average the sensed pressures in separate internal manifolds.
 5. Certification: Rate and test performance in accordance with AMCA 610.
 6. Performance:
 - a. Flow Accuracy: Within [2][3]<Insert number> percent of actual airflow.
 - b. Flow Velocity Range: [400 to 4000 fpm (2.0 to 20.3 m/s)][100 to 10,000 fpm (0.51 to 50.8 m/s)]<Insert flow velocity range>.
 - c. Pressure Loss: [0.025 inch wg (6.3 Pa) at 2000 fpm (10 m/s), or 0.085 inch wg (22.5 Pa) at 4000 fpm (20 m/s)]<Insert pressure loss requirements>.
 - d. Temperature Range: [Minus 20 to plus 200 deg F (Minus 19 to plus 93 deg C)]<Insert temperature range>.
 7. Airflow Probe Array: Construct field-installed duct arrays using either anodized extruded-aluminum probe(s) or stainless steel probe(s), depending on duct material. Each airflow traverse probe consists of multiple total and static pressure sensors located along its exterior surface, and internally connected to their respective averaging manifolds. The flow sensors are not to protrude beyond the surface of the probe(s). Locate total and static pressure sensors at the centers of equal areas for rectangular ducts and at equal concentric area centers for circular ducts across the duct cross sectional area.
 - a. For aluminum ducts, use anodized extruded-aluminum probes.
 - b. For galvanized-steel ducts, use anodized extruded-aluminum probes.
 - c. For stainless steel ducts, use Type 316 stainless steel probes.
 - d. External Pressure Signal Ports: Locate on exterior of casing and properly label each port: "Total (high)" and "Static (low)." Terminate each port with [1/4-inch (6-mm)] <Insert size> metal compression fittings for field connection to tubing.
 - e. Probe Mounting Accessories: Factory supply each probe with mounting plates, brackets, gaskets, and hardware specific for each application.
 - 1) For anodized extruded-aluminum probes, use aluminum mounting plates and brackets with stainless steel hardware.
 - 2) For stainless steel probes, use Type 316 stainless steel mounting plates, brackets, and hardware.
 8. Identification: Permanent identification label on each probe indicating model number and application-specific attributes.
 9. Flow Signal: Interconnect individual airflow probes in the field and mate to airflow transmitters [with 0.10 accuracy and auto-zero feature][with 0.25 accuracy and auto-zero feature]<Insert airflow transmitter type> for airflow measurement.
- F. Velocity Pressure Probe-Type Fan Inlet Airflow Traverse Sensor:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Air Monitor; an ONICON Brand]
 - b. [Paragon Controls Incorporated]

- c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[Paragon Controls Incorporated]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all velocity pressure probe-type fan inlet airflow traverse sensors from a single manufacturer.
4. Description: Traverse manifold designed for mounting in fan inlets.
 - a. Manifold contains multiple total- and static-pressure sensors placed at concentric area centers along the exterior surface of cylindrical manifold and internally connected to their respective averaging manifolds.
 - b. Do not protrude beyond the surface of the manifold.
5. Performance:
 - a. Design sensors so performance is not adversely affected by particle contamination present in the airstream.
 - b. Sensors capable of producing steady, non-pulsating signals of standard total and static pressure without need for flow corrections or factors, with an accuracy of **[3]<Insert number>** percent of actual flow over a turndown range of **[6]<Insert value>** to 1.
6. Construction:
 - a. Manifold (two per inlet) with dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings.
 - b. Manifold Materials: **[Copper or anodized aluminum][or][Type 316 stainless steel]**.
 - c. Copper or Anodized Aluminum Manifolds: Unless otherwise required by application and without affecting the fan and sensor performance, use the following sizes:
 - 1) For fan inlets smaller than **20 inches (500 mm)**, use **0.375-inch (9-mm)** diameter.
 - 2) For fan inlets **20 inches (500 mm)** and larger, use **0.75-inch (19-mm)** diameter.
 - d. Type 316 Stainless Steel Manifolds: Unless otherwise required by application and without affecting the fan and sensor performance, use the following sizes:
 - 1) For fan inlets smaller than **20 inches (500 mm)**, use **0.375-inch (9-mm)** diameter.
 - 2) For fan inlets **20 through 48 inches (500 through 1200 mm)**, use **0.75-inch (19-mm)** diameter.
 - 3) For fan inlets larger than **48 inches (1200 mm)**, use **1.0-inch (25-mm)** diameter.
7. Flow Signal: Mate the fan inlet sensors in field to airflow transmitters **[with 0.10 accuracy and auto-zero feature][with 0.25 accuracy and auto-zero feature]<Insert airflow transmitter type>** for airflow measurement.

G. Piezometer Ring Fan Inlet Airflow Sensor:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [ebm-papst Inc.]
 - b. [Twin City Fan & Blower]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ebm-papst Inc.]
 - b. [Twin City Fan & Blower]
 - c. <Insert manufacturer's name>
3. Source Limitations: Obtain all piezometer ring fan inlet airflow sensors from a single manufacturer.
4. Description:
 - a. In lieu of externally mounted fan inlet airflow sensors, option to provide fans with airflow measurement integral to fan inlet cones for continuous measurement of airflow rate.
 - b. Piezometer ring consists of multiple pressure sensor points strategically placed along the circumference of the fan inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.
 - c. Sensor points are not to protrude beyond the surface of the inlet cone or be adversely affected by particle contamination present in the airstream.
 - d. Standard offering of the fan manufacturer with published literature and supporting test data to validate performance.
5. Performance:
 - a. Produces steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.
 - b. Non-intrusive and not impacting fan performance.
6. Construction: Manufacturer's standard construction[, except use copper tubing and brass fittings in lieu of poly tubing].

H. Outdoor Airflow-Measurement System Using Differential Static Pressure:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Air Monitor; an ONICON Brand]
 - b. [ONICON Incorporated]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Air Monitor; an ONICON Brand]
 - b. [ONICON Incorporated]
 - c. <Insert manufacturer's name>

3. Manufacturer needs to confirm that overall system and each system component complies with requirements.
4. Description: Flow measurement system using principle of differential static pressure across a known fixed resistance. System consists of a temperature sensor with one or more airflow (pressure) sensors connected to a remotely mounted microprocessor-based monitor/transmitter.
 - a. Include one outdoor airflow-measurement system for each outdoor airflow-measurement application indicated on Drawings.
 - b. Report airflow readings in either actual or standard conditions. Correct values for altitude and temperature.
 - c. System is to directly measure airflow through an outdoor air inlet opening and report the measured airflow values through the monitor/transmitter local display, multiple analog outputs, and a single serial output for BACnet or Modbus.
5. Certification:
 - a. AMCA certified for airflow-measurement accuracy when installed as a complete system.
 - b. Class A device in accordance with 47 CFR, Chapter I - "Federal Communications Commission," Part 15 - "Radio Frequency Devices," Subpart A - "General"; Subpart B - "FAA Notification Criteria."
 - c. Submit product certificates showing compliance.
6. Application: Manufacturer's factory engineering is to review each separate outdoor airflow application indicated on Drawings and select a system solution that complies with requirements indicated.
 - a. Factory calibrate and configure system based on application and installation configuration.
 - b. Possible installation applications to include the following:
 - 1) Air hoods included with HVAC equipment.
 - 2) Air louvers included with HVAC equipment.
 - 3) Casing included as part of this outdoor airflow-measurement system for field installation.
 - 4) Other applications indicated on Drawings.
 - c. Possible airflow-measurement applications to include the following:
 - 1) Minimum outdoor airflow only.
 - 2) Total outdoor airflow (combined minimum and air economizer) measured as one value and reported as one value.
 - 3) Split Outdoor Airflows (Minimum and Air Economizer): Each airstream measured separately and reported separately, plus reported total airflow of combined airstreams.
 - 4) Dual outdoor airflow paths: Two airflows from a single transmitter.
7. Outdoor Duty:
 - a. Performance not impacted by presence of dirt, debris, moisture, rain, and snow in the measured airstream.
 - b. Performance not affected by wind direction, wind speed, and rapid changes in either, such as wind gusts, that are common in an outdoor environment.
 - c. Measured airflow corrected for ambient temperature and atmospheric pressure.
 - d. System components rated for outdoor duty, including interconnecting cable between temperature sensor and transmitter.

8. Performance:
 - a. Accuracy:
 - 1) Flow: Combined system accuracy within 5 percent of flow reading over entire operating range.
 - 2) Temperature: Within 0.1 percent at **32 deg F (0 deg C)**.
 - b. Adjustability: Accommodates changes in system operating parameters.
 - c. Airflow Range (Extended): 15 percent above design airflow and 15 percent below minimum airflow indicated on Drawings.
 - d. Auto Zero Feature:
 - 1) Accuracy: Within 0.1 percent of scale.
 - 2) Frequency: Configurable.
 - e. Velocity Range: **100 to 2400 fpm (0.51 to 12.2 m/s)**.
 - f. Repeatability: Within 0.2 percent.
 - g. Ambient Temperature: **Minus 40 to plus 120 deg F (Minus 40 to plus 49 deg C)**.
 - h. Ambient Humidity: Zero to 99 percent relative humidity, noncondensing.
9. Casing:
 - a. Where required by the measurement application, factory mount airflow sensor(s) and temperature sensor, and flatten expanded metal screen in an airflow station casing to create a single assembly for field mounting.
 - b. Material: **[Aluminum, 0.08 inch (2 mm) thick][Galvanized steel, 14 gauge thick][Type 304 stainless steel, 0.0781 inch (1.9 mm) thick][Type 316 stainless steel, 0.0781 inch (1.9 mm) thick]<Insert material>**.
 - 1) Factory prep, treat, and paint weld-damaged galvanized surfaces with a galvanize paint for corrosion protection comparable to adjacent undamaged galvanized surfaces.
 - c. Joints and Seams: Continuously or intermittently welded and sealed.
 - d. End Connections: Inlet and discharge ends of casing fitted with a flange face not less than **1.5 inches (38 mm)**.
 - e. Flattened Expanded Metal Screen:
 - 1) Material: **[Aluminum, nominal 3/4-inch- (20-mm-) diamond mesh, 1/8-inch- (3-mm-) thick strands][Hot-dipped galvanized steel, nominal 1/2-inch- (13-mm-) thick diamond mesh, 0.077-inch- (2-mm-) thick stands][Type 304 stainless steel, nominal 3/4-inch- (20-mm-) thick diamond mesh, 0.077-inch- (2-mm-) thick stands][Type 316 stainless steel, nominal 3/4-inch- (20-mm-) thick diamond mesh, 0.077-inch- (2-mm-) thick stands]**.
 - 2) Open Area: Not less than **[60]<Insert number>** percent.
 - f. Internally manifold pressure sensor(s) together using nominal **1/4-inch- (6-mm-)** diameter **[Type 304][or][Type 316]** stainless steel tubing with compression fittings and extend to exterior of casing for field connection.
10. Airflow (Pressure) Sensor(s):
 - a. Material: Type 316 stainless steel.
 - b. Quantity: Determined by manufacturer's factory engineering personnel for each measurement application.

- c. Size: Determined by manufacturer's factory engineering personnel for each measurement application.
- 11. Temperature Sensor: Three-wire, 100- or 1000-ohm platinum RTD in stainless steel sheath.
- 12. Monitor/Transmitter:
 - a. Enclosure:
 - 1) Rating: NEMA 250, Type 4.
 - 2) Cover: Hinged with display window.
 - 3) Conduit Connection: Two, **1/2-inch (13-mm)** trade size.
 - 4) Process Connections: Four **1/4-inch- (6-mm-)** compression fittings for receiving high/low inputs from two distinct flow arrays.
 - b. Local Display: Nominal **0.4-inch- (10-mm-)** diagonal color graphic LCD display.
 - c. Memory: Program parameters and data stored in nonvolatile FLASH memory.
 - d. Operator Interface: Field programmable; through menu using keypad on face of cover.
 - 1) Units: Selectable between IP or SI for flow, temperature, and velocity.
 - e. Power Supply: 24 V ac, isolated and fused with reverse polarity protection.
 - f. Remote Control Interface:
 - 1) Hardwired Analog Outputs: Three analog outputs, field selectable via menu for 4 to 20 mA, zero to 5 V dc, or zero to 10 V dc.
 - 2) Analog Output Scaling: Field-programmable scaling of velocity, flow, and temperature based on configuration. Provide field characterization of flow rate. System to allow for a separate K factor for each of three known flow rates.
 - 3) Serial Communication Interface: Field-selectable RS-485 network communications, either BACnet MS/TP or Modbus RTU.
 - g. Terminal Strip:
 - 1) Screw- or plug-in connections.
 - 2) Label each wiring connection.

2.4 AIRFLOW SWITCHES

A. Polymer Film Sail Airflow Switch:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Honeywell International Inc.]**
 - b. **[Johnson Controls, Inc.]**
 - c. **[Penn Controls]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Honeywell International Inc.]**
 - b. **[Johnson Controls, Inc.]**
 - c. **[Penn Controls]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all polymer film sail airflow switches from a single manufacturer.
 4. Description: Vane-operated airflow switch.
 5. Performance:
 - a. Electrical: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 1) Normally Closed Full Load Current: **[1]<Insert value> A** at 120 V ac.
 - 2) Normally Open Full Load Current: **[2]<Insert value> A** at 120 V ac.
 - 3) Voltage: 24, 120, and 240 V ac.
 - b. Mounting: Suitable for mounting with air direction in horizontal, vertical (up or down).
 - c. Temperature:
 - 1) Maximum Ambient Temperature: **[125 deg F (52 deg C)]<Insert temperature>**.
 - 2) Maximum Process Temperature: **[170 deg F (77 deg C)]<Insert temperature>**.
 - d. Velocity:
 - 1) Suitable for applications operating at velocities of up to **[400 fpm (2.0 m/s)]<Insert velocity>**.
 - 2) Normally open switch actuates at **[250 fpm (1.3 m/s)]<Insert velocity>** and opens at **[75 fpm (0.4 m/s)]<Insert velocity>**.
 - 3) Normally closed switch actuates at **[75 fpm (0.4 m/s)]<Insert velocity>** and closes at **[250 fpm (1.3 m/s)]<Insert velocity>**.
 6. Construction:
 - a. Polyester film sail encasing a wire frame.
 - b. Sail actuates a SPDT snap switch.
 - c. Removable spring counterbalances sail to allow mounting in either vertical (up or down) or horizontal airflow.
 - d. Enclosure:
 - 1) Material: Zinc-plated steel.
 - 2) Removable cover.
 - 3) Rating: NEMA 250, Type 1 enclosure.
 - 4) Wiring Connections: Labeled screw terminals.
 - 5) Conduit Connections: **1/2-inch (16-mm)** trade size conduit knock outs on top and bottom.

B. Stainless Steel Single-Vane Airflow Switch:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Dwyer Instruments, Inc]**
 - b. **[Johnson Controls, Inc.]**
 - c. **[Penn Controls]**

- d. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Dwyer Instruments, Inc]
 - b. [Johnson Controls, Inc.]
 - c. [Penn Controls]
 - d. <Insert manufacturer's name>
- 3. Source Limitations: Obtain all stainless steel single-vane airflow switches from a single manufacturer.
- 4. Description: Vane-operated airflow switch.
 - a. Suitable for mounting with air direction in horizontal.
- 5. Performance:
 - a. Electrical:
 - 1) Full Load Current: [9.8]<Insert value> A at 125 V ac.
 - 2) Voltage: 125, 240, and 480 V ac.
 - b. Temperature:
 - 1) Maximum Ambient Temperature: [125 deg F (52 deg C)]<Insert temperature>.
 - 2) Maximum Process Temperature: [180 deg F (82 deg C)]<Insert temperature>.
 - c. Velocity: Up to [2000 fpm (10.2 m/s)]<Insert velocity>.
 - 1) Field-Adjustable Velocity Set Point: [400 to 1600 fpm (2.0 to 8.2 m/s)]<Insert velocity range>.
- 6. Construction:
 - a. Stainless steel vane.
 - b. Vane actuates a SPDT snap switch.
 - c. Screw set-point adjustment.
 - d. Enclosure:
 - 1) Material: Die-cast metal.
 - 2) Enclosure with removable cover.
 - 3) Rating: NEMA 250, Type 1.
 - 4) Wiring Connections: Labeled screw terminals.
 - 5) Conduit Connections: 1-inch (27-mm) trade size conduit knock outs on top and bottom.

2.5 AIRFLOW TRANSMITTERS

A. Airflow Transmitter with 0.10 Percent Accuracy and Auto-Zero Feature:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Air Monitor; an ONICON Brand]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Air Monitor; an ONICON Brand]
 - b. <Insert manufacturer's name>
3. Description: Smart transmitter receives total- and static-pressure signals from a sensor (primary element), amplifies signals, extracts the square root, and scales the signals to produce 4 to 20 mA dc output signals linear to airflow and velocity or pressure.
 - a. Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals to re-zero transmitter to within 0.1 percent of true zero.
4. Performance:
 - a. Range: As required by application with range of at least [10]<Insert number> percent below minimum airflow and [10]<Insert number> percent greater than design airflow.
 - b. Calibrated Span: Field adjustable, minus 40 percent of the range.
 - c. Accuracy: Within 0.10 percent of natural span.
 - d. Repeatability: Within 0.15 percent of calibrated span.
 - e. Linearity: Within 0.2 percent of calibrated span.
 - f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
 - g. Pressure: Surges of up to 25 psig (172 kPa) will not harm transmitter.
 - h. Relative Humidity: Zero to 95 percent, noncondensing.
 - i. Temperature: 40 to 140 deg F (4 to 60 deg C).
 - j. Turndown: Flow and velocity turndown of 10 to 1; velocity pressure turndown of 100 to 1.
 - k. Vibration: Shock and vibration will neither harm transmitter, nor affect its performance.
5. Output Signals:
 - a. Analog Outputs. Two outputs, individually configurable for zero to 5 V dc, zero to 10 V dc, or 4 to 20 mA.
 - b. Digital Outputs:
 - 1) Form C dry contacts rated for 3 A at 24 V ac/V dc for high and low alarms.
 - 2) Dual Form A dry contacts rated for 3 A at 24 V ac/V dc for auto-purge activation and acknowledgment.
6. Network Communication: [BACnet][or][Modbus TCP/IP].
7. Enclosure:
 - a. Circuit Protection. Power input isolated, fused, and reverse polarity protected.
 - b. Display:
 - 1) Integral backlit LCD digital display on face of enclosure with [two][four] lines of data display, with each line individually scalable in user-selectable format and units of measure. For high visibility, display flow has easy-to-read, oversized digits and other

- variables with standard-size digits.
 - 2) LEDs indicate CPU activated, auto-zero in progress, auto-zero over-ranged, auto purge in progress, and auxiliary alarm "on" status.
 - c. Noise Filter. Adjustable response time to reach 98 percent of a step change from 2 to 250 seconds.
 - d. Rating: NEMA 250, **[Type 1][or][Type 4]**.
 - e. Wiring Connections: Labeled screw terminals concealed within enclosure.
 - f. Conduit Connections: Two trade-size conduit connections for connection to field-installed conduit.
 - g. Process Connections: Total (high) pressure and static (low) pressure ports with **[1/8-inch (3-mm)] [1/4-inch (6-mm)]<Insert size>** metal compression fittings for field connection to tubing.
 8. Operator Interface: Transmitter configuration, parameter setting, zero and span calibration, plus display formatting and scaling performed digitally in the onboard microprocessor via input pushbuttons on face of enclosure.
 9. Power: 24 V ac or V dc or 120 V ac via external transformer.
- B. Airflow Transmitters with 0.25 Percent Accuracy and Auto-Zero Feature:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
 3. Description: Smart transmitter receives total- and static-pressure signals from a sensor (primary element), amplifies signals, extracts the square root, and scales the signals to produce 4 to 20 mA dc output signals linear to airflow.
 - a. Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals to re-zero transmitter to within 0.1 percent of true zero.
 4. Performance:
 - a. Range: As required by application and at least **[10]<Insert number>** percent below minimum airflow and **[10]<Insert number>** percent greater than design airflow.
 - b. Calibrated Span: Field adjustable, minus 40 percent of range.
 - c. Accuracy: Within 0.25 percent of natural span.
 - d. Repeatability: Within 0.15 percent of calibrated span.
 - e. Linearity: Within 0.2 percent of calibrated span.
 - f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.

- g. Pressure: Surges of up to **25 psig (172 kPa)** will not harm transmitter.
 - h. Relative Humidity: Zero to 95 percent, noncondensing.
 - i. Temperature: **40 to 140 deg F (4 to 60 deg C)**.
 - j. Turndown: Flow and velocity turndown of 10 to 1; velocity pressure turndown of 100 to 1.
 - k. Vibration: Shock and vibration will neither harm transmitter, nor affect its performance.
5. Output Signals:
- a. Analog Outputs. One output configurable for zero to 5 V dc, zero to 10 V dc, or 4 to 20 mA.
6. Enclosure:
- a. Circuit Protection. Power input isolated, fused, and reverse polarity protected.
 - b. Display: Integral backlit LCD digital display on face of enclosure for continuous indication of airflow.
 - c. Noise Filter. Adjustable response time to reach 98 percent of a step change from 2 to 250 seconds.
 - d. Rating: NEMA 250, **[Type 1][Type 4][or][Type 12]**.
 - e. Wiring Connections: Labeled screw terminals concealed within enclosure.
 - f. Conduit Connections: Trade size conduit connections to field-installed connection.
 - g. Process Connections: Total (high) pressure and static (low) pressure ports with **[1/8-inch (3-mm)] [1/4-inch (6-mm)][3/8-inch (9-mm)] <Insert size>** metal compression fittings for field connection to tubing.
7. Power: 24 V ac or V dc.
- C. Pressure Differential Transmitters for Airflow Measurement:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **[Paragon Controls Incorporated]**
 - c. **[Setra Systems Inc.]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **[Paragon Controls Incorporated]**
 - c. **[Setra Systems Inc.]**
 - d. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain all pressure differential transmitters for airflow measurement from a single manufacturer.
 - 4. Description: Transmitter receives total- and static-pressure signals from a sensor (primary element) and sends output signal(s) for airflow.
 - 5. Performance:
 - a. Range: As required by application and at least **[10]<Insert number>** percent below minimum airflow and **[10]<Insert number>** percent greater than design airflow.
 - b. Accuracy: Within **[0.5][0.4][0.25]** percent of the full-scale range.

- c. Hysteresis: Within **[0.10]<Insert number>** percent of full scale.
 - d. Repeatability: Within **[0.05]<Insert number>** percent of full scale.
 - e. Stability: Within **[1.0]<Insert number>** percent of span per year.
 - f. Overpressure: **[10 psig (69 kPa)]<Insert pressure>**.
 - g. Temperature Limits: **[0 to 150 deg F (Minus 18 to plus 66 deg C)]<Insert temperature range>**.
 - h. Compensate Temperature Limits: **[40 to 150 deg F (4 to 66 deg C)]<Insert temperature range>**.
 - i. Thermal Effects: **[0.033]<Insert number>** percent of full scale per **deg F (deg C)**.
 - j. Vibration: Shock and vibration will not harm the transmitter.
6. Output Signals:
- a. Analog Current Signal:
 - 1) Two-wire, 4 to 20 mA dc current source.
 - 2) Signal capable of operating into **[800]<Insert value>**-ohm load.
 - b. Analog Voltage Signal:
 - 1) Three wire, zero to **[5][10]** V.
 - 2) Minimum Load Resistance: **[1000]<Insert value>** ohms.
7. Display: Digital display with minimum **0.4-inch- (10-mm-)** high numeric characters.
8. Operator Interface:
- a. Zero and span adjustments located behind cover.
9. Construction:
- a. Enclosure Material: Plastic casing with removable plastic cover.
 - b. Enclosure Rating: NEMA 250, **[Type 4]<Insert type>**.
 - c. Fittings: Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing.
 - d. Mounting: Vertical plane mounting.
 - e. Mounting Bracket: Appropriate for installation.
 - f. Wiring Connections: Labeled screw terminals.
 - g. Conduit Connections: Trade-size conduit connections to field-installed connection
- D. Pressure Differential Indicating Transmitter, Switch, and Controller for Airflow Measurement:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**

3. Description:
 - a. Three-in-one instrument, including digital display, control relay switches, and a transmitter with a current output.
 - b. Field configurable for pressure, velocity, and volumetric flow applications through user interface.
 - c. Select instrument range based on application.
4. Performance:
 - a. Accuracy including hysteresis and repeatability:
 - 1) Within 1.5 percent for range of **0.25 inch wg (63 Pa)**.
 - 2) Within 1 percent for ranges of **0.5 to 5-inch wg (125 to 1250 Pa)**.
 - 3) Within 0.5 percent for ranges greater than **5 inch wg (1250 Pa)**.
 - b. Stability: Within 1 percent per year.
 - c. Response Time: 250 ms.
 - d. Overpressure:
 - 1) Ranges less than **50 inch wg (12.5 kPa)** with overpressure of **9 psi (62 kPa)**.
 - 2) Range of **50 inch wg (12.5 kPa)** with overpressure of **15 psi (103 kPa)**.
 - 3) Range of **100 inch wg (25 kPa)** with overpressure of **20 psi (138 kPa)**.
 - e. Temperature Limits: **32 to 140 deg F (0 to 60 deg C)**.
 - f. Thermal Effects: 0.020 percent of full scale per **deg F (deg C)**.
 - g. Warmup Period: One hour.
5. Controller: Programming through menu keys to access five menus.
 - a. Security level.
 - b. Pressure, velocity, or flow application.
 - c. Engineering units.
 - d. K-factor for use with flow application.
 - e. Set-point control only; set-point and alarm operation; alarm operation as high, low, or high/low with manual; or automatic reset and delay.
 - f. View high and low readings.
 - g. Digital dampening for smoothing erratic applications.
 - h. Scaling of analog output to fit range and field calibration.
6. Display:
 - a. Four-digit digital, with minimum **0.4-inch- (10-mm-)** high alphanumeric characters.
 - b. Four LED indicators; two LEDs for set point and two LEDs for alarm status.
7. Operator Interface:
 - a. Set-point adjustment through keypad on face of instrument.
 - b. Zero and span adjustments accessible through menu.
 - c. Programming through keypad.
8. Output Analog Signal: Two-wire, 4 to 20 mA dc current source; capable of operating into a 900-ohm load.
9. Output Digital Signal: Two, SPDT relays; each rated for 1 A at 30 V ac or 30 V dc.
10. Construction:

- a. Enclosure Rating: NEMA 250, Type 1.
- b. Face Size: Nominal 4-inch- (100-mm-) diameter.
- c. Materials: Die-cast aluminum casing and [stainless steel]bezel.
- d. Mounting: Vertical plane mounting.
- e. Mounting Bracket: Appropriate for installation.
- f. Process Connections: 1/8-inch- (3-mm-) NPT, on side and back.

2.6 LIQUID FLOW METERS

A. General Requirements for Liquid Flow Meters:

1. Adjustable for changes in system operational parameters.
2. Liquid Sensors, Meters, and Transmitters: Extended range of [10][20]<Insert number> percent above Project design flow and [10][20]<Insert number> percent below Project minimum flow to signal abnormal flow conditions.
3. Manufacturer is to certify that each flow instrument indicated complies with specified performance requirements and characteristics.
4. Product certificates are required.

B. Insertion Impeller Liquid Flow Meters with Accuracy of 1 Percent of Full Scale:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Badger Meter, Inc.]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Badger Meter, Inc.]
 - b. <Insert manufacturer's name>
3. Description: Insertion-type meter with a non-magnetic spinning impeller (paddle wheel).
4. Meter Size Range: [NPS 3 through NPS 36 (DN 80 through DN 900)]<Insert pipe size range>.
5. Process Pipe Connection: NPS 2 (DN 50).
6. Performance:
 - a. Ambient Temperature: 14 to 150 deg F (Minus 10 to plus 66 deg C).
 - b. Flow Velocity Range: 0.3 to 30 fps (0.09 to 9.1 m/s).
 - c. Flow Accuracy: Within 1 percent of full scale over flow range.
 - d. Linearity: Within 0.2 percent of full scale over flow range.
 - e. Repeatability: Within 0.3 percent of full scale over flow range.
 - f. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: 400 psig at 100 deg F (2758 kPa at 38 deg C).
 - 2) Minimum Temperature Range: Up to [221 deg F (105 deg C)][285 deg F (141 deg C)].
7. Output Signal: Frequency pulse.

8. Construction:

- a. Wetted Metal Parts, Including Sensor Sleeve, Mounting Adapter, and Isolation Valve: **[Brass][or]Type 316 stainless steel**.
- b. Shaft: **[Tungsten carbide][or]Type 316 stainless steel**.
- c. Impeller: **[Nylon][or]ETFE**.
- d. Process Connection: **NPS 2 (DN 50)**.
- e. Instrument Isolation Valve: **[Gate][Full port ball]** valve for system isolation.
- f. Insertion Depth: Threaded positioning nut for accurate sensor depth in the pipe.
- g. Electronics Enclosure:
 - 1) Polyphenylene sulfide (PPS) with Viton seal.
 - 2) Electrical Connection: Cable furnished with sensor.

9. Transmitter:

- a. User-adjustable scale to refine resolution of flow range of over 4 to 20 mA signal.
- b. Enclosure Material: Polycarbonate with tongue and groove, with neoprene-sealed cover.
- c. Enclosure Rating: NEMA 250, Type 4X.
- d. Electrical Connection: Labeled screw terminals.
- e. Linearity of less than 1 percent.
- f. Output Response Time: 6 seconds for 10 to 90 percent step.
- g. Load resistance of 650 ohms at 24 V dc.
- h. Digital display of flow rate.

C. Insertion Impeller Liquid Flow Meters with 0.5 Percent Accuracy:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Badger Meter, Inc.]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Badger Meter, Inc.]**
 - b. **<Insert manufacturer's name>**
- 3. Description: Insertion-type flow meter with a non-magnetic spinning impeller (paddle wheel).
 - a. Include programming kit with cable connector and Microsoft-Windows-compatible software.
 - b. Where indicated, provide meter with bidirectional flow measurement.
- 4. Factory Calibration: Wet calibrate each meter to standards traceable to NIST. Tag each meter and provide each meter with a certificate of calibration.
- 5. Meter Size Range: **[NPS 1-1/2 through NPS 36 (DN 40 through DN 900)]<Insert pipe size range>**.
- 6. Process Pipe Connection: **NPS 1 (DN 25)**.
- 7. Performance:
 - a. Ambient Temperature: **14 to 150 deg F (Minus 10 to plus 66 deg C)**.
 - b. Flow Velocity Range: **0.5 to 20 fps (0.15 to 6.1 m/s)**.

- c. Flow Accuracy: Within 0.5 percent of flow rate.
 - d. Repeatability: Within 0.5 percent.
 - e. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: **350 psig (2413 kPa)** with PEEK sensor tip.
 - 2) Minimum Temperature Range: Up to **300 deg F (149 deg C)** with PEEK sensor tip.
 - f. Pressure Drop: Up to **0.5 psig at 10 fps (3.5 kPa at 3 m/s)** for pipe sizes **NPS 1-1/2 (DN 40)** and larger.
8. Output Signal:
- a. Unidirectional Flow Meter:
 - 1) Frequency pulse.
 - 2) Analog, two-wire, loop-powered, 4 to 20 mA signal.
 - 3) Scaled pulse.
 - b. Bidirectional Flow Meter:
 - 1) Provide analog 4 to 20 mA signal plus direction.
 - 2) Scaled pulse.
9. Operator Interface:
- a. Programming: Instrument programming through computer and programming kit.
 - b. Digital Display: Eight-character digital display of flow rate, flow totalization, input, output, and flow direction for bidirectional meters.
10. Construction:
- a. Wetted Metal Parts (Including Sensor Stem, Mounting Adapter, and Isolation Valve): Type 316 stainless steel[**or brass**].
 - b. Sensor Tip: PPS or PEEK.
 - c. Shaft: Tungsten carbide.
 - d. Impeller: Stainless steel.
 - e. Process Connection: **NPS 1 (DN 25)**.
 - f. Instrument Isolation Valve: Full port ball valve for system isolation.
 - g. Insertion Depth: Threaded positioning nut for accurate sensor depth in pipe.
 - h. Electronics Enclosure:
 - 1) Material: Polypropylene with Viton-sealed acrylic cover.
 - 2) Removable cover.
 - 3) Rating: NEMA 250, Type 4X.
 - 4) Electrical Connection: Labeled screw terminals.
 - 5) Conduit Connection: **1/2-inch (16-mm)** trade size.
- D. Insertion Turbine Liquid Flow Meters:
- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. **[Badger Meter, Inc.]**
 - b. **[ONICON Incorporated]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Badger Meter, Inc.]**
 - b. **[ONICON Incorporated]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all insertion turbine flow meters from a single manufacturer.
4. Description: Turbine rotational sensing accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).
5. Factory Calibration: Wet calibrate each meter to standards traceable to NIST. Tag each meter and provide each meter with a certificate of calibration.
6. Meter Size Range: **[NPS 1-1/4 through NPS 72 (DN 32 through DN 1800)]<Insert pipe size range>**.
7. Process Pipe Connection: **[NPS 1 (DN 25)]<Insert pipe size>**.
8. Performance:
 - a. Ambient Temperature: **[Minus 5 to plus 160 deg F (Minus 21 to plus 71 deg C)]<Insert temperature range>**.
 - b. Conductivity: Suitable for flow measurement of fluids with electrical conductivity of greater than **[5][100]<Insert conductivity>** microseimens per centimeter.
 - c. Flow Velocity Range: **[0.1 to 30 fps (0.03 to 9.1 m/s)]<Insert flow velocity range>**.
 - d. Flow Accuracy: Within **[1]<Insert number>** percent of reading for flow velocities between **[3 to 30 fps (0.9 to 9.1 m/s)]<Insert flow velocity range>** and within **[2]<Insert number>** percent of reading for flow velocities between **[0.4 to 20 fps (0.12 to 6.1 m/s)]<Insert flow velocity range>**.
 - e. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: **[400 psig (2758 kPa)]<Insert value>**.
 - 2) Minimum Temperature Range:
 - a) Chilled and Condenser Water Systems: **[Minus 20 to plus 150 deg F (Minus 29 to plus 66 deg C)]<Insert temperature range>**.
 - b) Heating Water Systems: Within **[minus 20 to plus 280 deg F (minus 29 to plus 138 deg C)]<Insert temperature range>**.
 - f. Pressure Drop: **[Less than 0.16 psig (1.1 kPa) at 8 fps (2.4 m/s) and decreasing at lower velocities]<Insert pressure drop>**.
9. Meter Construction:
 - a. Installation Hardware: Include installation hardware necessary to enable insertion and removal from pipe without system shutdown.
 - 1) Isolation Valve: Full-port **[Type 316 stainless steel]**ball valve.
 - b. Turbines:

- 1) Single turbines for pipe sizes **NPS 2 (DN 50)** and smaller.
 - 2) Dual turbines for pipe sizes **NPS 2-1/2 (DN 65)** and larger.
 - 3) Dual turbines for bidirectional flow applications.
 - 4) Dual turbines with dual, contra-rotating turbine elements; each turbine element with its own rotational sensing system and an averaging circuit.
 - 5) Materials: Polypropylene with sapphire jewel bearings and tungsten carbide shafts.
- c. Wetted Metal Components: Type 316 stainless steel[**or bronze- and nickel-plated brass**], including installation hardware.
- d. Enclosure:
 - 1) Rating: NEMA 250, Type 4 enclosure; Type 6 for submersible applications.
 - 2) Wiring Connections: Labeled terminal strip.
 - 3) Conduit Connections: Suitable for mating to field-installed conduit.
10. Meter Cable: As required by manufacturer for field application.
11. Output Signals:
 - a. Frequency: Frequency output linear with flow rate. Meter has dual turbines, with individual top and bottom outputs for diagnostic purposes.
 - b. Digital, Scaled Pulse: Isolated solid-state dry contacts with a contact rating of 100 mA at 50 V with programmable contact duration.
 - c. Analog: Field programmable, 4 to 20 mA, zero to 5 V, or zero to 10 V.
 - d. Isolated Analog: Field programmable, 4 to 20 mA, zero to 5 V, or zero to 10 V.
12. Bluetooth Connectivity:
 - a. Version: 5.1 or later; low energy (BLE).
 - b. Mode: Single.
 - c. Connectivity Range: 50 ft.
13. Remote Display Unit:
 - a. Enclosure Rating: NEMA 250, Type 4 or 4X.
 - b. Wiring Connections: Labeled terminal strip.
 - c. Conduit Connections: **1/2-inch (16-mm)** trade size.
 - d. Remote Signal Interface:
 - 1) Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero to 10 V dc.
 - 2) Outputs linear to within 0.1 percent of calibrated span.
 - 3) Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.
 - e. Digital Display: Backlit, LCD display of flow rate and totalized flow.
 - 1) At least eight display digits for totalization; local reset of flow totalization.
 - 2) Bidirectional units with separate digital display for flow and totalization in each direction.
 - 3) Bidirectional units with display of flow direction (contacts open or closed).
14. Memory: Store program and data in nonvolatile memory.
15. Power: 120 to 240 V ac; 50 to 60 Hz power supply with 24 V dc output to power the flow sensor.

E. In-Line Body Turbine Liquid Flow Meters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Badger Meter, Inc.]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Badger Meter, Inc.]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
3. Description: Turbine rotational sensing accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).
4. Factory Calibration: Wet calibrate each meter to standards traceable to NIST. Tag each meter and provide each meter with a certificate of calibration.
5. Meter Size Range: **NPS 3/4 through NPS 1 (DN 20 through DN 25).**
6. Performance:
 - a. Ambient Temperature: **Minus 5 to plus 160 deg F .**
 - b. Flow Accuracy:
 - 1) Within 2 percent of actual flow between flow range of **0.8 to 38 gpm (0.05 to 2.4 L/s).**
 - 2) Within 0.5 percent of actual reading at calibrated velocity.
 - c. Process Pressure and Temperature: Suitable for maximum system pressure and temperature.
 - 1) Minimum Pressure: **400 psig (2758 kPa).**
 - 2) Minimum Temperature: **250 deg F (121 deg C).**
 - d. Pressure Drop: Not to exceed **0.48 psig (21 kPa at 2.4 L/s)** at maximum flow.
7. Construction:
 - a. Sensor is to have an integral frequency output linear with flow rate.
 - b. Body End Connections: Threaded union on each end.
 - c. Turbine Materials: Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts.
 - d. Wetted Metal Parts Material: Brass or stainless steel.
 - e. Electronics Enclosure Rating: NEMA 250, Type 4; Type 6 for submersible applications.
 - f. Enclosure with conduit connection(s) for field-installed conduit.
 - g. Sensor cable of length sufficient to connect to display module.
8. Display Module:
 - a. Remote from meter.
 - b. Enclosure Rating: NEMA 250, Type 4 or 4X.
 - c. Electrical Connections: Labeled terminal strip.
 - d. Conduit Connections: Two, **1/2-inch (16-mm)** trade size.

e. Remote Interface:

- 1) Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero to 10 V dc.
- 2) Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.
- 3) Outputs linear to within 0.1 percent of calibrated span.

f. Digital display of flow rate and totalized flow.

g. At least eight display digits for totalization.

h. Local reset of flow totalization.

9. Memory: Store program and data in nonvolatile memory.

10. Power: 120 to 240 V ac; 50 or 60 Hz power supply with 24 V dc output to power the flow sensor.

F. In-line Body Electromagnetic Liquid Flow Meters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. **[Armstrong International, Inc]**
- b. **[Badger Meter, Inc.]**
- c. **[ONICON Incorporated]**
- d. **[Spirax Sarco Limited]**
- e. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Armstrong International, Inc]**
- b. **[Badger Meter, Inc.]**
- c. **[ONICON Incorporated]**
- d. **[Spirax Sarco Limited]**
- e. **<Insert manufacturer's name>**

3. Source Limitations: Obtain all in-line body electromagnetic flow meters from a single manufacturer.

4. Description: In-line body flow meter using electromagnetic technology.

- a. No moving parts.
- b. Continuous auto-zero function.
- c. Inherent bidirectional flow measurement.
- d. Flow-measurement applications with **[three]<Insert number>** pipe diameters upstream and **[two]<Insert number>** pipe diameters downstream.

5. Factory Calibration: Wet calibrate each meter to standards traceable to NIST. Tag each meter and provide each meter with a certificate of calibration.

6. Meter Size Range: **[NPS 1 through NPS 48 (DN 25 through DN 1200)]<Insert pipe size range>**.

7. Performance:

- a. Ambient Temperature: **[Minus 4 to plus 140 deg F (Minus 20 to plus 60 deg C)]<Insert**

- a. [Dwyer Instruments, Inc]
 - b. [ONICON Incorporated]
 - c. [Spirax Sarco Limited]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Dwyer Instruments, Inc]
 - b. [ONICON Incorporated]
 - c. [Spirax Sarco Limited]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain all insertion electromagnetic flow meters from a single manufacturer.
4. Description: Insertion-style flow meter using electromagnetic technology.
 - a. No moving parts.
 - b. Continuous auto-zero function.
 - c. Transmitter integral to meter.
5. Factory Calibration: Wet calibrate each meter to standards traceable to NIST. Tag each meter and provide each meter with a certificate of calibration.
6. Meter Size Range: [NPS 1-1/4 through NPS 72 (DN 32 through DN 1800)]<Insert pipe size range>.
7. Process Pipe Connection: [NPS 1 (DN 25)]<Insert pipe size>.
8. Performance:
 - a. Ambient Temperature: [Minus 20 to plus 150 deg F (Minus 29 to plus 66 deg C)]<Insert temperature range>.
 - b. Conductivity: Suitable for flow measurement of fluids with electrical conductivity between [20 to 60,000]<Insert conductivity range> microseimens per centimeter.
 - c. Flow Velocity Range: [0.1 to 20 fps (0.03 to 6.1 m/s)]<Insert flow velocity range>.
 - d. Flow Accuracy: Within [1]<Insert number> percent of reading for flow velocities between [2 to 20 fps (0.6 to 6.1 m/s)]<Insert flow velocity range> and within [0.02 fps (0.006 m/s)]<Insert flow velocity> of reading for flow velocities [2 fps (0.6 m/s)]<Insert flow velocity> and less.
 - e. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: [400 psig (2758 kPa)]<Insert value>.
 - 2) Minimum Temperature Range: Within [15 to 250 deg F (minus 9 to plus 121 deg C)]<Insert temperature range>.
 - f. Pressure Drop: [See Drawings]<Insert pressure drop>.
9. Output Signals:
 - a. Field-selectable analog signals.
 - 1) Current Signal (Isolated): 4 to 20 mA.
 - 2) Voltage Signal (Isolated): Zero to [5][10] V dc.
 - b. Digital Signal: Dry-contact closure signaling fault condition.
 - c. Frequency Signal: Zero to 15 V peak pulse; zero to 500 Hz.

- d. Scalable Pulse Output:
 - 1) Isolated solid-state dry contact.
 - 2) Contact Rating: **[100 mA at 50 V dc]<Insert contact rating>**.
 - 3) Pulse Duration: **[0.5, 1, 2, or 6]<Insert duration>** seconds.
10. Construction:
 - a. Wetted Metal Parts: Type 316 stainless steel.
 - b. Sensor Head: **[XAREC][Polysulfone]<Insert material>**.
 - c. Process Connection: **1 inch (25 mm)**.
 - d. Instrument Isolation Valve: Full port Type 316 stainless steel ball valve for system isolation.
 - e. Electrodes: Type 316 stainless steel.
 - f. Electronics Enclosure:
 - 1) Material: Painted aluminum.
 - 2) Removable cover.
 - 3) Rating: NEMA 250, Type 4.
 - 4) Electrical Connections: PVC-jacketed cable, **[10 ft. (3 m)]<Insert length>** long.
 - 5) Conduit Connections: **1/2-inch (16-mm)** trade size.
11. Display Module:
 - a. Location: Remote from meter.
 - b. Enclosure Rating: NEMA 250, Type 4X.
 - c. Wiring Connections: Labeled terminal strip.
 - d. Power: 24, 120, or 240 V ac; 50 or 60 Hz power supply, unless otherwise required by application, with 24 V dc output to power the flow sensor.
 - e. Input Signal from Meter: Zero to 15 V pulse output.
 - f. Output Signals: Additional output signals furnished with flow meter connected to display module terminal strip.
 - g. Auxiliary Output Signals:
 - 1) Analog Current Output (Isolated): 4 to 20 mA.
 - 2) Analog Voltage Output (Isolated): Zero to **[5][10]** V.
 - 3) Digital output (isolated): Solid-state dry contacts rated for 100 mA at 50 V.
 - h. Serial Communication: RS-485, two wire; **[BACnet][or][Modbus RTU]** protocol.
 - i. Digital Display: Flow rate and totalized flow with local reset of flow totalization.
 - 1) At least six display digits for flow rate and eight display digits for totalization.
 - 2) Bidirectional units with separate digital display for flow and totalization in each direction.
 - 3) Bidirectional units with LED display of flow direction (contacts open or closed).
12. Memory: Store program and data in nonvolatile memory.
- H. In-Line Body Thermal Mass Liquid Flow Meters:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ONICON Incorporated]**
 - b. **[Spirax Sarco Limited]**

- c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ONICON Incorporated]
 - b. [Spirax Sarco Limited]
 - c. <Insert manufacturer's name>
3. Source Limitations: Obtain all in-line body thermal mass flow meters from a single manufacturer.
4. Description:
 - a. Application: Intended for flow measurement of natural gas, propane, and compressed air.
 - b. Direct measurement of mass flow from a pair of encapsulated platinum sensors without need for additional pressure and temperature compensation.
 - c. Program each meter using project-specific application data.
 - d. Meter with integral diagnostics to verify installation conditions and proper operation.
5. Factory Calibration: Factory calibrate each meter at not less than [five]<Insert number> points across meter flow range against manufacturer's flow standards. Tag meter and provide a certificate of calibration.
6. Meter Size Range: [NPS 1/2 through NPS 6 (DN 15 through DN 150)]<Insert pipe size range>.
7. Performance:
 - a. Ambient Temperature: [Minus 40 to plus 150 deg F (Minus 40 to plus 66 deg C)]<Insert temperature range>.
 - b. Mass Flow Accuracy: Within [1]<Insert number> percent of reading for flow range of [500 to 7000 sfpm (2.54 to 35.6 sm/s)]<Insert flow range> and within [2]<Insert number> percent of reading for flow range of [100 to 500 sfpm (0.51 to 2.54 sm/s)]<Insert flow range>.
 - c. Repeatability: Within [0.1]<Insert number> percent.
 - d. Long-Term Stability: Within [0.1]<Insert number> percent per year.
 - e. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: [200 psig (1379 kPa)]<Insert value>.
 - 2) Minimum Temperature Range: Within [minus 40 to plus 250 deg F (minus 40 to plus 121 deg C)]<Insert temperature range>.
 - f. Pressure Drop: [See Drawings]<Insert pressure drop>.
8. Output Signals:
 - a. Analog Current Signal of Flow Rate:
 - 1) Two-wire, 4 to 20 mA dc current source.
 - 2) Signal capable of operating into [1000]<Insert value>-ohm load.
 - b. Digital Signal:
 - 1) Pulse Output for Flow Totalization: Two wire, scaled pulse, 0.5 Hz, 100 mA at 30 V dc.

9. Serial Communication: RS-485, two wire; **[BACnet][or][Modbus RTU]** protocol.
 10. Operator Interface:
 - a. Keypad with field programming of all parameters; local reset of flow totalization.
 - b. Digital Display: Two-line digital display of alphanumerical characters; displaying flow rate, flow totalization, and temperature.
 11. Construction:
 - a. Enclosure:
 - 1) Material: Epoxy-painted cast aluminum.
 - 2) Removable screw-on cover.
 - 3) Mounting: **[Integral][or][remote]**
 - 4) Rating: NEMA 250, Type 4X.
 - 5) Electrical Connections: Labeled screw terminals.
 - 6) Conduit Connections: Two, **3/4-inch (21-mm)** trade size.
 - b. Meter Body: In-line body for field installation in piping.
 - c. Meter Body End Connections: ASME B16.5 flanges, Class 150.
 - d. Meter Materials: Type 316L stainless steel.
 - e. Flow Conditioner: Integral to meter body.
 - f. Memory: Store program and data in nonvolatile memory.
 12. Power: **[120 or 240 V ac; 50 or 60 Hz field power source with field-installed ac-to-dc power supply to convert alternating current source (V ac) to direct current source (V dc) to power the meter]<Insert power requirements>** unless otherwise required by application.
- I. Vortex-Shedding Liquid Flow Meters with Integral Temperature Measurement:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Armstrong International, Inc]**
 - b. **[ONICON Incorporated]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[ONICON Incorporated]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain all vortex-shedding flow meters with integral temperature measurement from a single manufacturer.
 4. Description:
 - a. Flow measurement using vortex shedder body with integral 1000-ohm platinum RTD.
 - b. Program each meter using project-specific application data.
 - c. Meter with integral diagnostics to verify installation conditions and proper operation.

5. Factory Calibration: Factory calibrate each meter at not less than **[five]<Insert number>** points across meter flow range against manufacturer's flow standards. Tag meter and provide a certificate of calibration.
6. Meter Size Range: **[NPS 1/2 through NPS 8 (DN 15 through DN 200)]<Insert pipe size range>**.
7. Performance:
 - a. Ambient Temperature: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>**.
 - b. Volumetric Flow Accuracy: Within **[0.7]<Insert number>** percent of reading for Reynolds numbers **[10,000]<Insert value>** and larger.
 - c. Repeatability: Within **[0.2]<Insert number>** percent.
 - d. Long-Term Stability: Within **[0.2]<Insert number>** percent per year.
 - e. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: **[200 psig (1379 kPa)][400 psig (2758 kPa)]<Insert value>**.
 - 2) Minimum Temperature Range: Within **[minus 330 to plus 500 deg F (minus 201 to plus 260 deg C)]<Insert temperature range>**.
 - f. Pressure Drop: **[See Drawings]<Insert pressure drop>**.
8. Output Signals:
 - a. Analog Current Signal of Flow Rate:
 - 1) Two-wire, 4 to 20 mA dc current source.
 - 2) Signal capable of operating into **[1000]<Insert value>**-ohm load.
 - b. Analog Current Signals for Temperature: 4 to 20 mA.
 - c. Digital Signal:
 - 1) Pulse Output for Flow Totalization: Two wire, scaled pulse, 0.5 Hz, 100 mA at 30 V dc.
9. Serial Communication: RS-485, two wire; **[BACnet][or][Modbus RTU]** protocol.
10. Operator Interface:
 - a. Keypad with field programming of all parameters; local reset of flow totalization.
 - b. Digital Display: Two-line digital display of alphanumerical characters; displaying flow rate, flow totalization.
11. Construction:
 - a. Enclosure:
 - 1) Material: Epoxy-painted cast aluminum.
 - 2) Removable screw-on cover.
 - 3) Mounting: Integral to meter.
 - 4) Rating: NEMA 250, Type 4X.
 - 5) Electrical Connections: Labeled screw terminals.
 - 6) Conduit Connection: Two, **1/2-inch (16-mm)** trade size.
 - b. Meter End Connections: ASME B16.5 flanges; class required by performance.
 - c. Meter Material: Type 316L stainless steel.

- d. Memory: Store program and data in nonvolatile memory.
- 12. Power: **[120 or 240 V ac; 50 or 60 Hz]<Insert power requirements>** unless otherwise required by application.
- 13. Upstream Flow Straightener:
 - a. Application: Include meter with flow straightener where required by meter manufacturer for specific installation.
 - b. Material: Type 316 stainless steel.
 - c. Size: Match meter.
 - d. Type: Flanged, or wafer designed for installation between field-installed flanges.
- J. Vortex-Shedding Liquid Flow Meters with Integral Pressure and Temperature Measurement:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[Badger Meter, Inc.]**
 - c. **[ONICON Incorporated]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[Badger Meter, Inc.]**
 - c. **[ONICON Incorporated]**
 - d. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain all vortex-shedding flow meters with integral pressure and temperature measurements from a single manufacturer.
 - 4. Description:
 - a. Mass flow measurement corrected for density using vortex shedder body with integral piezoelectric pressure sensors and 1000-ohm platinum RTD.
 - b. Program each meter using project-specific application data.
 - c. Meter with integral diagnostics to verify installation conditions and proper operation.
 - 5. Factory Calibration: Factory calibrate each meter at not less than **[five]<Insert number>** points across meter flow range against the manufacturer's flow standards. Tag meter and provide a certificate of calibration.
 - 6. Meter Size Range: **[NPS 1/2 through NPS 8 (DN 15 through DN 200)]<Insert pipe size range>**.
 - 7. Performance:
 - a. Ambient Temperature: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>**.
 - b. Volumetric Flow Accuracy: Within **[0.7]<Insert number>** percent of reading for Reynolds numbers **[10,000]<Insert value>** and larger.
 - c. Repeatability: Within **[0.2]<Insert number>** percent.
 - d. Long-Term Stability: Within **[0.2]<Insert number>** percent per year.
 - e. Process Pressure and Temperature: Suitable for system maximum operating pressure and

temperature.

- 1) Minimum Pressure: [200 psig (1379 kPa)][400 psig (2758 kPa)]<Insert value>.
- 2) Minimum Temperature Range: Within [minus 330 to plus 500 deg F (minus 201 to plus 260 deg C)]<Insert temperature range>.

f. Pressure Drop: [See Drawings]<Insert pressure drop>.

8. Output Signals:

a. Analog Current Signal of Flow Rate:

- 1) Two-wire, 4 to 20 mA dc current source.
- 2) Signal capable of operating into [1000]<Insert value>-ohm load.

b. Analog Current Signals for Pressure and Temperature: Separate 4 to 20 mA signals for gage pressure and temperature.

c. Digital Signal:

- 1) Pulse Output for Flow Totalization: Two wire, scaled pulse, 0.5 Hz, 100 mA at 30 V dc.

9. Serial Communication: RS-485, two wire; [BACnet][or][Modbus RTU] protocol.

10. Operator Interface:

- a. Keypad with field programming of all parameters; local reset of flow totalization.
- b. Digital Display: Two-line digital display of alphanumerical characters; displaying flow rate, flow totalization, pressure, and temperature.

11. Meter Construction:

a. Enclosure:

- 1) Material: Epoxy-painted cast aluminum.
- 2) Removable screw-on cover.
- 3) Mounting: [Integral][or][remote].
- 4) Rating: NEMA 250, Type 4X.
- 5) Electrical Connection: Labeled screw terminals.
- 6) Conduit Connection: Two, 1/2-inch (16-mm) trade size.

b. Meter End Connections: ASME B16.5 flanges; class required by performance.

c. Meter Material: Type 316L stainless steel.

d. Memory: Store program and data in nonvolatile memory.

12. Power: [120 or 240 V ac; 50 or 60 Hz]<Insert power requirements> unless otherwise required by application.

13. Upstream Flow Straightener:

- a. Application: Include meter with flow straightener where required by meter manufacturer for specific installation.
- b. Material: Type 316 stainless steel.
- c. Size: Match meter.
- d. Type: Flanged, or wafer designed for installation between field-installed flanges.

K. Vortex-Shedding Liquid Flow Meters for Hazardous Environments:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **[Spirax Sarco Limited]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **[Spirax Sarco Limited]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all vortex-shedding flow meters for hazardous environments from a single manufacturer.
4. Standard: ASME MFC-6.
5. Description:
 - a. FM Approved for hazardous environments.
 - 1) Intrinsically safe for Class I, Division 1, Groups A, B, C, and D; Class II and III, Division 1, Groups E, F, and G.
 - 2) Explosion proof for Class I, Division 1, Groups B, C, and D.
 - 3) Dust ignition proof for Class II and III, Division 1, Groups E, F, and G.
 - b. Sensor isolated from process and replaceable without breaking process seals.
 - c. Clog-free design eliminates gaskets and ports.
 - d. Each meter furnished with a permanently attached stainless steel tag.
 - e. Meter with integral diagnostics to verify proper operation.
6. Factory Calibration: Factory calibrate each meter and provide with a certificate of calibration.
7. Meter Size Range: **[NPS 1/2 through NPS 12 (DN 15 through DN 300)]<Insert pipe size range>**.
8. Performance:
 - a. Ambient Temperature: **[Minus 4 to plus 185 deg F (Minus 20 to plus 85 deg C)]<Insert temperature range>**.
 - b. Ambient Humidity: Zero to 95 percent noncondensing.
 - c. Flow Accuracy: Within **[0.65]<Insert number>** percent of reading plus 0.025 percent of span for Reynolds numbers 20000 and larger.
 - d. Repeatability: Within **[0.1]<Insert number>** percent of flow rate.
 - e. Long-Term Stability: Within **[0.1]<Insert number>** percent of flow rate per year.
 - f. Response Time: Greater of three vortex-shedding cycles or **[0.2]<Insert value>** seconds.
 - g. Dampening: Adjustable between **[0.2 to 255]<Insert value>** seconds.
 - h. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: **[200 psig (1379 kPa)][400 psig (2758 kPa)]<Insert value>**.
 - 2) Minimum Temperature Range: Within **[minus 40 to plus 450 deg F (minus 40 to plus 232 deg C)]<Insert temperature range>**.

- i. Pressure Drop: **[See Drawings]<Insert pressure drop>**.
 - j. Vibration: Meter immune to vibration.
9. Output Signals:
- a. Analog Current Signal of Flow Rate:
 - 1) Two-wire, 4 to 20 mA dc current source.
 - 2) Signal capable of operating into **[1000]<Insert value>-ohm load**.
 - b. Digital Signal:
 - 1) Pulse output for flow totalization.
 - 2) HART protocol.
10. Digital Display: Digital display of alphanumerical characters; displaying flow rate, flow totalization, percent of range, and current output.
11. Body and Flanges:
- a. Material: Type 316L stainless steel.
 - b. Connections: ASME B16.5, class required by performance.
12. Enclosure:
- a. Materials: Polyurethane-painted cast aluminum.
 - b. Removable screw-on cover.
 - c. Rating: NEMA 250, Type 4X.
 - d. Electrical Connections: Labeled screw terminals.
 - e. Conduit Connections: **1/2-inch (16-mm)** trade size.
13. Power: **[120 or 240 V ac; 50 or 60 Hz]<Insert power requirements>** unless otherwise required by application.
14. Upstream Flow Straightener:
- a. Application: Include meter with flow straightener where required by meter manufacturer for specific installation.
 - b. Material: Type 316 stainless steel
 - c. Size: Match meter.
 - d. Type: Flanged, or wafer designed for installation between field-installed flanges.
- L. Compact In-Line Body Ultrasonic Liquid Flow Sensor:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Badger Meter, Inc.]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[ONICON Incorporated]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Badger Meter, Inc.]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[ONICON Incorporated]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all compact in-line body ultrasonic flow sensors from a single manufacturer.
4. Description:
 - a. Flow Sensing Method: No moving parts; direct beam path wetted ultrasonic sensors utilizing differential transit time velocity measurement.
 - b. Programming:
 - 1) Configure and program each meter at factory for specific application without need for field programming. Field programming is to be available through user interface or serial interface using an operator workstation.
 - 2) Store program parameters and totaled values in nonvolatile memory.
 - c. Battery: Back-up real-time clock and calendar with lithium battery.
 - d. Approvals: BTL certified to ASHRAE 135.
5. Factory Calibration: Factory calibrate each meter against manufacturer's NIST-traceable flow standards and provide a certificate of calibration for each meter.
6. Meter Size Range: **[NPS 1/2 through NPS 2-1/2 (DN 13 through DN 65)]<Insert pipe size range>**.
7. Performance:
 - a. Ambient Temperature: **[Minus 10 to plus 130 deg F (Minus 23 to plus 54 deg C)]<Insert value>**.
 - b. Ambient Humidity: 5 to 90 percent relative humidity, noncondensing.
 - c. Flow accuracy of 1 percent for flow range:
 - 1) NPS 1/2 (DN 13): **[0.6 to 15 gpm (0.038 to 0.95 L/s)]<Insert flow range>**.
 - 2) NPS 3/4 (DN 20): **[0.6 and 15 gpm (0.038 and 0.95 L/s)]<Insert flow range>**.
 - 3) NPS 1 (DN 25): **[1 to 25 gpm (0.063 to 1.58 L/s)]<Insert flow range>**.
 - 4) NPS 1-1/4 (DN 32): **[3 to 60 gpm (0.189 to 3.78 L/s)]<Insert flow range>**.
 - 5) NPS 1-1/2 (DN 40): **[5 to 100 gpm (0.315 to 6.31 L/s)]<Insert flow range>**.
 - 6) NPS 2 (DN 50): **[8 to 150 gpm (0.505 to 9.46 L/s)]<Insert flow range>**.
 - 7) NPS 2-1/2 (DN 65): **[12 to 225 gpm (0.757 to 14.19 L/s)]<Insert flow range>**.
 - d. Flow accuracy of 2 percent for flow range:
 - 1) NPS 1/2 (DN 13): **[0.15 and 0.6 gpm (0.0009 and 0.038 L/s)]<Insert flow range>**.
 - 2) NPS 3/4 (DN 20): **[0.15 and 0.6 gpm (0.009 and 0.038 L/s)]<Insert flow range>**.
 - 3) NPS 1 (DN 25): **[0.25 and 1.0 gpm (0.016 and 0.063 L/s)]<Insert flow range>**.
 - 4) NPS 1-1/4 (DN 32): **[0.6 and 3.0 gpm (0.038 and 0.189 L/s)]<Insert flow range>**.
 - 5) NPS 1-1/2 (DN 40): **[1.0 and 5.0 gpm (0.063 and 0.315 L/s)]<Insert flow range>**.
 - 6) NPS 2 (DN 50): **[1.5 and 8.0 gpm (0.095 and 0.505 L/s)]<Insert flow range>**.
 - 7) NPS 2-1/2 (DN 65): **[2.5 and 12 gpm (0.158 and 0.758 L/s)]<Insert flow range>**.
 - e. Minimum Flow Rate:
 - 1) NPS 1/2 (DN 13): **[0.03 gpm (0.002 L/s)]<Insert value>**.
 - 2) NPS 3/4 (DN 20): **[0.03 gpm (0.002 L/s)]<Insert value>**.
 - 3) NPS 1 (DN 25): **[0.05 gpm (0.003 L/s)]<Insert value>**.
 - 4) NPS 1-1/4 (DN 32): **[0.12 gpm (0.008 L/s)]<Insert value>**.

- 5) NPS 1-1/2 (DN 40): **[0.20 gpm (0.013 L/s)]<Insert value>**.
- 6) NPS 2 (DN 50): **[0.30 gpm (0.019 L/s)]<Insert value>**.
- 7) NPS 2-1/2 (DN 65): **[0.50 gpm (0.032 L/s)]<Insert value>**.
- f. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: **[400 psig (2758 kPa)]<Insert value>**.
 - 2) Minimum Temperature Range: **[32 to 250 deg F (0 to 121 deg C)]<Insert temperature range>**.
- g. Pressure Drop: **[1.5 psig (10 kPa)]<Insert value>** or less at following flow rate:
 - 1) NPS 1/2 (DN 13): **[6.6 gpm (0.42 L/s)]<Insert value>**.
 - 2) NPS 3/4 (DN 20): **[6.6 gpm (0.42 L/s)]<Insert value>**.
 - 3) NPS 1 (DN 25): **[11 gpm (0.69 L/s)]<Insert value>**.
 - 4) NPS 1-1/4 (DN 32): **[26 gpm (1.64 L/s)]<Insert value>**.
 - 5) NPS 1-1/2 (DN 40): **[44 gpm (2.78 L/s)]<Insert value>**.
 - 6) NPS 2 (DN 50): **[66 gpm (4.16 L/s)]<Insert value>**.
 - 7) NPS 2-1/2 (DN 65): **[110 gpm (6.94 L/s)]<Insert value>**.
8. Network Connection:
 - a. TIA RS-485 serial interface.
 - b. ASHRAE 135, native BACnet MS/TP protocol.
 - c. Communicates flow rate, interval data and network status.
9. Input Signals:
 - a. Three isolated totalizing pulse inputs for use with sinking open collector or dry contacts.
 - b. Rating: 30 V dc, 10 mA maximum.
 - c. Pulse duration of 50 ms.
 - d. Totals accumulated at meter, displayed locally and remotely through network connection.
10. Analog Output Signal: 4 to 20 mA flow rate signal.
11. Digital Output Signals:
 - a. Indicating: Volume or alarm.
 - b. Rating: 30 V dc, 50 mA.
 - c. Pulse Duration: **[50][100][500][1000]** ms.
12. Display:
 - a. Integral to meter and detachable for remote field mounting.
 - b. Backlight alphanumeric display and operator interface.
 - c. Same information communicated to network available on display.
13. Meter:
 - a. Enclosure:
 - 1) Polycarbonate with removable screw-on cover.
 - 2) Rating: IEC 60529 IP65 or NEMA 250, Type 4.
 - 3) Electrical Connections: Labeled screw terminals.
 - 4) Conduit Connections: Two; trade size.

- b. End Connections:
 - 1) Sizes through NPS 2 (DN 50): Threaded, MNPT.
 - 2) NPS 2-1/2 (DN 65): Flange face for mating to ASME B16.5, Class 150 raised face flange.
- c. Wetted Materials: Lead-free brass, containing not more than 15 percent zinc (DZR and corrosion resistant), and PEEK.
- 14. Power Supply:
 - a. Field Power: 24 V ac; 50 or 60 Hz unless otherwise required by application.
- M. Clamp-On Ultrasonic Liquid Flow Sensors:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[Badger Meter, Inc.]**
 - c. **[Dwyer Instruments, Inc]**
 - d. **[ONICON Incorporated]**
 - e. **[Spirax Sarco Limited]**
 - f. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[Badger Meter, Inc.]**
 - c. **[Dwyer Instruments, Inc]**
 - d. **[ONICON Incorporated]**
 - e. **[Spirax Sarco Limited]**
 - f. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain all clamp-on ultrasonic flow sensors from a single manufacturer.
 - 4. Description:
 - a. Flow-Sensing Method: Non-invasive with no moving parts; ultrasonic differential transit time velocity measurement using nonwetted transducers. Method is suitable for use with clear fluids in pressurized metallic and nonmetallic pipes that are full.
 - b. Programming:
 - 1) Configure and program each meter at factory for specific application without need for field programming. Field programming is available through user interface or serial interface using an operator workstation.
 - 2) Store program parameters and totalized values in nonvolatile memory.
 - c. Battery: Back-up real-time clock and calendar with lithium battery.
 - d. Data Logger: Integral data log with minimum **[128]<Insert value>** megabytes of storage.
 - 5. Factory Calibration: Factory calibrate each meter against manufacturer's NIST-traceable flow standards and provide a certificate of calibration for each meter

6. Performance:
 - a. Ambient Humidity: 5 to 90 percent relative humidity, noncondensing.
 - b. Ambient Operating Temperature: [Minus 5 to plus 140 deg F (Minus 21 to plus 60 deg C)]<Insert temperature range>.
 - c. Flow Sensor Accuracy:
 - 1) Accuracy for Velocities between [1 and 20 fps (0.3 to 6.1 m/s)]<Insert velocity range>: Within [1]<Insert number> percent of reading.
 - 2) Accuracy for Velocities Less than [1 fps (0.3 m/s)]<Insert velocity>: Within [0.01 fps (0.003 m/s)]<Insert velocity>.
 - d. Flow Sensor Pressure Drop: No permanent pressure drop.
 - e. Flow Sensor Velocity Range: [0.07 to 40 fps (0.02 to 12.2 m/s)]<Insert flow velocity range>.
 - f. Process Pipe Sizes: [NPS 1/2 (DN 13)]<Insert pipe size> through [NPS 48 (DN 1200)]<Insert pipe size>.
 - g. Process Temperature: Suitable for system maximum operating temperature.
7. Meter Display and Operator Interface: Backlit, LCD alphanumeric display of the following on face of meter enclosure:
 - a. Flow rate.
 - b. Power status (on/off).
8. Meter Enclosure:
 - a. Remote mounted from temperature and flow sensors.
 - b. Rating: IEC 60529 IP67 or NEMA 250, Type 4X.
 - c. Construction: Polycarbonate with hinged cover.
 - d. Electrical and Control Cable Connections: Labeled screw terminals.
 - e. Conduit Connections: Manufacturer standard; trade size suitable for mating to field-installed conduit.
9. Input Signals:
 - a. Three isolated totalizing pulse inputs for use with sinking open collector or dry contacts.
 - b. Rating: 30 V dc, 10 mA maximum.
 - c. Pulse duration of 50 ms.
 - d. For use in totalizing pulses from external devices.
 - e. Totals accumulated at meter, displayed locally and remotely through network connection.
10. Output Signals:
 - a. Flow Rate: 4 to 20 mA or zero to 10 V dc.
11. Serial Network Interface:
 - a. TIA RS-485 serial interface for remoted monitoring.
 - b. ASHRAE 135, native BACnet MS/TP protocol.
 - c. Communicate energy consumption and rate, flow rate, supply and return temperature, peak and average values, interval data, and network status.
12. Power Supply:

- a. Field Power: 24, 120, or 240 V ac; 50 or 60 Hz as required by the application.
- b. Internal Power: As required by flow meter.

13. Transducers:

- a. Housing: Type 316 stainless steel; NEMA 250, Type 4 with trade-size conduit connections.
- b. Mounting Kit: Type 304 or 316 stainless steel brackets and miscellaneous hardware; option to use 200 series stainless steel clamps.
- c. Sensor Cable: As required by manufacturer for application.

2.7 STEAM FLOW METERS

A. General Requirements for Steam Flow Meters:

- 1. Adjustable for changes in system operational parameters.
- 2. Steam Sensors, Meters, and Transmitters: Extended range of [10][20]<Insert number> percent above Project design flow and [10][20]<Insert number> percent below Project minimum flow to signal abnormal flow conditions.
- 3. Manufacturer is to certify that each flow instrument indicated complies with specified performance requirements and characteristics.
- 4. Product certificates are required.

B. Vortex-Shedding Steam Flow Meters with Integral Temperature Measurement:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[ONICON Incorporated]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[ONICON Incorporated]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain all vortex-shedding flow meters with integral temperature measurement from a single manufacturer.
- 4. Description:
 - a. Flow measurement using vortex-shedder body with integral 1000-ohm platinum RTD.
 - b. Program each meter using project-specific application data.
 - c. Meter with integral diagnostics to verify installation conditions and proper operation.
- 5. Factory Calibration: Factory calibrate each meter at not less than **[five]<Insert number>** points across meter flow range against manufacturer's flow standards. Tag meter and provide a certificate of calibration.
- 6. Meter Size Range: **[NPS 1/2 through NPS 8 (DN 15 through DN 200)]<Insert pipe size**

- range>.**
7. Performance:
- a. Ambient Temperature: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>.**
 - b. Mass Flow Accuracy: Within **[1.5]<Insert number>** percent of reading for Reynolds numbers **[10,000]<Insert value>** and larger.
 - c. Repeatability: Within **[0.2]<Insert number>** percent.
 - d. Long-Term Stability: Within **[0.2]<Insert number>** percent per year.
 - e. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: **[200 psig (1379 kPa)][400 psig (2758 kPa)]<Insert value>.**
 - 2) Minimum Temperature Range: Within **[minus 330 to plus 500 deg F (minus 201 to plus 260 deg C)]<Insert temperature range>.**
 - f. Pressure Drop: **[See Drawings]<Insert pressure drop>.**
8. Output Signals:
- a. Analog Current Signal of Flow Rate:
 - 1) Two-wire, 4 to 20 mA dc current source.
 - 2) Signal capable of operating into **[1000]<Insert value>-ohm** load.
 - b. Analog Current Signals for Temperature: 4 to 20 mA.
 - c. Digital Signal:
 - 1) Pulse Output for Flow Totalization: Two wire, scaled pulse, 0.5 Hz, 100 mA at 30 V dc.
9. Serial Communication: RS-485, two wire; **[BACnet][or][Modbus RTU]** protocol.
10. Operator Interface:
- a. Keypad with field programming of all parameters; local reset of flow totalization.
 - b. Digital Display: Two-line digital display of alphanumerical characters, displaying flow rate and flow totalization.
11. Construction:
- a. Enclosure:
 - 1) Material: Epoxy-painted cast aluminum.
 - 2) Removable screw-on cover.
 - 3) Mounting: Integral to meter.
 - 4) Rating: NEMA 250, Type 4X.
 - 5) Electrical Connections: Labeled screw terminals.
 - 6) Conduit Connection: Two, **1/2-inch (16-mm)** trade size.
 - b. Meter End Connections: ASME B16.5 flanges; class required by performance.
 - c. Meter Material: Type 316L stainless steel.
 - d. Memory: Store program and data in nonvolatile memory.
12. Power: **[120 or 240 V ac; 50 or 60 Hz]<Insert power requirements>** unless otherwise required by application.

13. Upstream Flow Straightener:

- a. Application: Include meter with flow straightener where required by meter manufacturer for specific installation.
- b. Material: Type 316 stainless steel.
- c. Size: Match meter.
- d. Type: Flanged or wafer designed for installation between field-installed flanges.

C. Vortex-Shedding Steam Flow Meters with Integral Pressure and Temperature Measurement:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[ONICON Incorporated]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all vortex-shedding flow meters with integral pressure and temperature measurements from a single manufacturer.
4. Description:
 - a. Mass flow measurement corrected for density using vortex-shedder body with integral piezoelectric pressure sensors and 1000-ohm platinum RTD.
 - b. Program each meter using project-specific application data.
 - c. Meter with integral diagnostics to verify installation conditions and proper operation.
5. Factory Calibration: Factory calibrate each meter at not less than **[five]<Insert number>** points across meter flow range against the manufacturer's flow standards. Tag meter and provide a certificate of calibration.
6. Meter Size Range: **[NPS 1/2 through NPS 8 (DN 15 through DN 200)]<Insert pipe size range>**.
7. Performance:
 - a. Ambient Temperature: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>**.
 - b. Mass Flow Accuracy: Within **[1.5]<Insert number>** percent of reading for Reynolds numbers **[10,000]<Insert value>** and larger.
 - c. Repeatability: Within **[0.2]<Insert number>** percent.
 - d. Long-Term Stability: Within **[0.2]<Insert number>** percent per year.
 - e. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: **[200 psig (1379 kPa)][400 psig (2758 kPa)]<Insert value>**.
 - 2) Minimum Temperature Range: Within **[minus 330 to plus 500 deg F (minus 201 to plus 260 deg C)]<Insert temperature range>**.

- f. Pressure Drop: **[See Drawings]<Insert pressure drop>**.
 - 8. Output Signals:
 - a. Analog Current Signal of Flow Rate:
 - 1) Two-wire, 4 to 20 mA dc current source.
 - 2) Signal capable of operating into **[1000]<Insert value>-ohm load**.
 - b. Analog Current Signals for Pressure and Temperature: Separate 4 to 20 mA signals for gage pressure and temperature.
 - c. Digital Signal:
 - 1) Pulse Output for Flow Totalization: Two wire, scaled pulse, 0.5 Hz, 100 mA at 30 V dc.
 - 9. Serial Communication: RS-485, two wire; **[BACnet][or][Modbus RTU]** protocol.
 - 10. Operator Interface:
 - a. Keypad with field programming of all parameters; local reset of flow totalization.
 - b. Digital Display: Two-line digital display of alphanumerical characters, displaying flow rate, flow totalization, pressure, and temperature.
 - 11. Meter Construction:
 - a. Enclosure:
 - 1) Material: Epoxy-painted cast aluminum.
 - 2) Removable screw-on cover.
 - 3) Mounting: **[Integral][or][remote]**.
 - 4) Rating: NEMA 250, Type 4X.
 - 5) Electrical Connection: Labeled screw terminals.
 - 6) Conduit Connection: Two, **1/2-inch (16-mm)** trade size.
 - b. Meter End Connections: ASME B16.5 flanges; class required by performance.
 - c. Meter Material: Type 316L stainless steel.
 - d. Memory: Store program and data in nonvolatile memory.
 - 12. Power: **[120 or 240 V ac; 50 or 60 Hz]<Insert power requirements>** unless otherwise required by application.
 - 13. Upstream Flow Straightener:
 - a. Application: Include meter with flow straightener where required by meter manufacturer for specific installation.
 - b. Material: Type 316 stainless steel.
 - c. Size: Match meter.
 - d. Type: Flanged or wafer designed for installation between field-installed flanges.
- D. Vortex-Shedding Steam Flow Meters for Hazardous Environments:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **[Spirax Sarco Limited]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **[Spirax Sarco Limited]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all vortex-shedding flow meters for hazardous environments from a single manufacturer.
4. Standard: ASME MFC-6.
5. Description:
 - a. FM Approved for hazardous environments.
 - 1) Intrinsically safe for Class I, Division 1, Groups A, B, C, and D; Class II and III, Division 1, Groups E, F, and G.
 - 2) Explosion proof for Class I, Division 1, Groups B, C, and D.
 - 3) Dust ignition proof for Class II and III, Division 1, Groups E, F, and G.
 - b. Sensor isolated from process and replaceable without breaking process seals.
 - c. Clog-free design eliminates gaskets and ports.
 - d. Each meter furnished with a permanently attached stainless steel tag.
 - e. Meter with integral diagnostics to verify proper operation.
6. Factory Calibration: Factory calibrate each meter and provide with a certificate of calibration.
7. Meter Size Range: **[NPS 1/2 through NPS 12 (DN 15 through DN 300)]<Insert pipe size range>**.
8. Performance:
 - a. Ambient Temperature: **[Minus 4 to plus 185 deg F (Minus 20 to plus 85 deg C)]<Insert temperature range>**.
 - b. Ambient Humidity: Zero to 95 percent noncondensing.
 - c. Flow Accuracy: Within **[0.65]<Insert number>** percent of reading plus 0.025 percent of span for Reynolds numbers 20000 and larger.
 - d. Repeatability: Within **[0.1]<Insert number>** percent of flow rate.
 - e. Long-Term Stability: Within **[0.1]<Insert number>** percent of flow rate per year.
 - f. Response Time: Greater of three vortex-shedding cycles or **[0.2]<Insert value>** seconds.
 - g. Dampening: Adjustable between **[0.2 to 255]<Insert value>** seconds.
 - h. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: **[200 psig (1379 kPa)][400 psig (2758 kPa)]<Insert value>**.
 - 2) Minimum Temperature Range: Within **[minus 40 to plus 450 deg F (minus 40 to plus 232 deg C)]<Insert temperature range>**.
 - i. Pressure Drop: **[See Drawings]<Insert pressure drop>**.
 - j. Vibration: Meter immune to vibration.
9. Output Signals:
 - a. Analog Current Signal of Flow Rate:

- 1) Two-wire, 4 to 20 mA dc current source.
 - 2) Signal capable of operating into [1000]<Insert value>-ohm load.
 - b. Digital Signal:
 - 1) Pulse output for flow totalization.
 - 2) HART protocol.
10. Digital Display: Digital display of alphanumeric characters, displaying flow rate, flow totalization, percentage of range, and current output.
11. Body and Flanges:
 - a. Material: Type 316L stainless steel.
 - b. Connections: ASME B16.5, class required by performance.
12. Enclosure:
 - a. Materials: Polyurethane-painted cast aluminum.
 - b. Removable screw-on cover.
 - c. Rating: NEMA 250, Type 4X.
 - d. Electrical Connections: Labeled screw terminals.
 - e. Conduit Connections: 1/2-inch (16-mm) trade size.
13. Power: [120 or 240 V ac; 50 or 60 Hz]<Insert power requirements> unless otherwise required by application.
14. Upstream Flow Straightener:
 - a. Application: Include meter with flow straightener where required by meter manufacturer for specific installation.
 - b. Material: Type 316 stainless steel.
 - c. Size: Match meter.
 - d. Type: Flanged or wafer designed for installation between field-installed flanges.

2.8 LIQUID FLOW SENSORS (PRIMARY ELEMENTS)

A. Averaging Pitot-Tube Liquid Flow Sensors:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Armstrong International, Inc]
 - b. [Preso Meters; Badger Meter Inc.]
 - c. [Rosemount; Emerson Electric Co., Automation Solutions]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Armstrong International, Inc]
 - b. [Preso Meters; Badger Meter Inc.]
 - c. [Rosemount; Emerson Electric Co., Automation Solutions]

- d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all averaging pitot-tube liquid flow sensors from a single manufacturer.
4. Standard: ASME MFC-12M.
5. Description:
 - a. Sensor cross-sectional shape to provide a flow separation at a fixed point independent of flow rate, pressure, or temperature with a stable flow coefficient maintained over a wide range of Reynolds numbers.
 - b. Sensor shape to promote less-turbulent zones on backside of sensor. Locate individual sensing ports in less-turbulent region to measure low pressure. Number of sensing ports is a function of pipe size.
 - c. Sensor high pressure measured by a frontal slot extending full length of sensor or a comparable design. Number of slots is a function of pipe size.
 - d. Manufacturer to submit on request independent testing documentation (product test reports), demonstrating compliance with specified performance.
 - e. Include sensor with flow signal isolation valves and connections that are suitable for connecting to a remote transmitter.
6. Performance: **[Product test reports are required.]**
 - a. Accuracy: Within **[0.75]<Insert number>** percent of measured flow over flow range from design flow to **[10]<Insert number>** percent of design flow.
 - b. Discharge Coefficient Factor: Within **[0.75]<Insert number>** percent of flow rate.
 - c. Repeatability: Within **[0.1]<Insert number>** percent.
 - d. Flow Range: **[10][17]<Insert value>** to 1 turndown.
 - e. Pressure and Temperature: Suitable for system pressure and temperature.
 - f. Pressure Drop: Up to **[3]<Insert number>** percent of full flow range pressure differential signal.
 - g. Pressure Differential Signal for Flow Measurement: Size orifice plates for approximately **[100 inch wg (24.9 kPa)]<Insert pressure>** pressure differential, except absolute value of meter range not to exceed absolute value of flowing pressure.
 - h. Size Range: **[NPS 2 through NPS 48 (DN 50 through DN 1200)]<Insert pipe size range>**.
7. Construction:
 - a. Sensor Surface Finish: Front surface textured for high-Reynolds-number applications if required to create a more turbulent boundary layer on front surface of sensor and produce a more predictable and repeatable separation of flow at edge of sensor.
 - b. Sensor Material: Type 316 stainless steel.
 - c. Packing Gland:
 - 1) Wetted Parts: Type 316 stainless steel.
 - 2) Packing Material: Graphite.
 - d. Isolation Valve: Type 316 stainless steel full port ball valve configured to remove sensor while isolating process.
 - e. Flanged In-line Pipe Spool:
 - 1) Factory mount sensor in a flanged section of pipe.
 - 2) Pipe material to match adjacent pipe.
 - 3) Flanges to match adjacent pipe.
 - f. Flow Signal Connections: **NPS 1/2 (DN 15)** NPT with Type 316 stainless steel needle valves.

- g. Identification: Attach tag to each averaging pitot-tube sensor with a chain and label indicating pipe size, sensor series, sensor reading at flow rate, and pressure differential.
- 8. Factory Calibration: Factory calibrate each averaging pitot-tube sensor specific to application.
- 9. Flow Signal: Mate averaging pitot-tube sensor in field to a pressure differential transmitter **[with high accuracy]** for flow measurement.

B. Venturi Liquid Flow Sensors:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[HCl; Hydronics Components Inc.]**
 - c. **[Preso Meters; Badger Meter Inc.]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[HCl; Hydronics Components Inc.]**
 - c. **[Preso Meters; Badger Meter Inc.]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain all venturi liquid flow sensors from a single manufacturer.
- 4. On request, submit independent testing documentation (product test reports), demonstrating compliance with specified performance.
- 5. Standard: ASME MFC-3M.
- 6. Performance:
 - a. Accuracy: Within **[0.25][0.5]<Insert number>** percent of measured flow over flow range from design flow to **[10]<Insert number>** percent of design flow.
 - 1) Accuracy with **[five]<Insert number>** pipe diameters of straight pipe upstream and **[two]<Insert number>** pipe diameters downstream.
 - b. Repeatability: Within **[0.1][0.2]<Insert number>** percent over the flow range.
 - c. Beta Ratio: Select between 0.30 and 0.75 to achieve performance indicated. Match venturi with transmitter to provide performance of entire assembly.
 - d. Flow Range: **[10]<Insert value>** to 1 turndown.
 - e. Pressure and Temperature: Suitable for system pressure and temperature.
 - f. Pressure Drop: Up to **[6][20]<Insert number>** percent of full flow range pressure differential signal.
 - g. Pressure Differential Signal for Flow Measurement: Size orifice plates for approximately **[100 inch wg (24.9 kPa)]<Insert pressure>** pressure differential, except absolute value of meter range not to exceed absolute value of flowing pressure.
 - h. Size Range: **[NPS 1/2 through NPS 48 (DN 15 through DN 1200)]<Insert pipe size range>**.
- 7. Construction:

- a. Body End Connections: Flanged[**or threaded (NPT) for sizes NPS 1/2 through NPS 2 (DN 15 through DN 50)**].
 - 1) Flanges: Suitable for mating to ASME B16.5 Class 150 or 300 pipe flanges as required by system pressure; **[welding neck][raised faces]**; material to match body.
 - b. Body Length: Length determined by manufacturer to comply with performance indicated.
 - c. Body Material: **[Carbon steel][or]** Type 316 or 316L stainless steel with inside diameter to match adjacent pipe.
 - 1) Optional Materials: Option to use one-piece bronze or brass construction with threaded FNPT end connections for pipe sizes **NPS 1/2 through NPS 2 (DN 15 to DN 50)**.
 - d. Throat Material: Type 316 stainless steel.
 - e. Flow Signal Connections: Two accurately located built-in sensing taps, nipples, and shut-off valves for field connection to transmitter; minimum size **NPS 1/2 (DN 15) NPT**.
 - f. Identification: Attach tag to each venturi with a chain and label indicating pipe size, venturi series, station identification, and reading at flow rate and pressure differential.
8. Factory Calibration: Factory calibrate each venturi specific to application.
9. Flow Signal: Mate venturi in field to a pressure differential transmitter[**with high accuracy**] for flow measurement.
- C. Orifice Plate Liquid Flow Sensors:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Armstrong International, Inc]**
 - b. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain all orifice plates from a single manufacturer.
 4. Description: Concentric with sharp, square-edge orifice plate with handle and adjoining matching companion flanges[**factory installed in a meter run**].
 5. Standards: ASME MFC-3M or ASME MFC-14M.
 6. Performance:
 - a. Accuracy: Within **[1][2][5]<Insert number>** percent of measured flow over flow range from design flow to **[10]<Insert number>** percent of design flow.
 - 1) Accuracy with **[10]<Insert number>** pipe diameters of straight pipe upstream and **[5]<Insert number>** pipe diameters downstream.

- b. Repeatability: Within **[0.2]<Insert number>** percent over flow range.
- c. Flow Range: **[5][10]<Insert value>** to 1 turndown.
- d. Pressure and Temperature: Suitable for system pressure and temperature.
- e. Pressure Drop: See Drawings.
- f. Pressure Differential Signal for Flow Measurement: Size orifice plates for approximately **[100 inch wg (24.9 kPa)]<Insert pressure>** pressure differential, except absolute value of meter range not to exceed absolute value of flowing pressure.
- g. Beta Ratio: Select ratio of orifice diameter to actual internal pipe diameter d/B (beta) between 0.30 and 0.70.
- h. Size Range: **[NPS 1/2 through NPS 24 (DN 15 through DN 600)]<Insert pipe size range>**.

7. Construction:

- a. End Connections: Matching companion flanges suitable for mating to ASME B16.5, Class 150 or 300 pipe flanges as required by system pressure. **[Flanges with welding neck][Flanges with welding neck and raised faces]**.
- b. Material: Fabricate orifice plate and matching companion flanges of Type 316 stainless steel **[or]<Insert material>**.
- c. Flow Signal Connections: **NPS 1/2 (DN 15) NPT**.
- d. Identification: Stamp orifice plates with number and orifice bore on handle of orifice plate.

8. Calibration: Include information and calculations for each orifice plate, showing compliance with ASME MFC-3M or ASME MFC-14M.

9. Flow Signal: Mate orifice plate assembly in field to a pressure differential transmitter **[with high accuracy]** for flow measurement.

D. Segmented-Wedge Liquid Flow Sensors:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Armstrong International, Inc]**
- b. **[Preso Meters; Badger Meter Inc.]**
- c. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Armstrong International, Inc]**
- b. **[Preso Meters; Badger Meter Inc.]**
- c. **<Insert manufacturer's name>**

3. Source Limitations: Obtain all segmented-wedge liquid flow sensors from a single manufacturer.

4. Description: Pressure differential design using a segmented or segmental wedge installed in a straight section of pipe. Design sensors for solids and particulates to be swept through the opening and for measurements with Reynolds Numbers down to 500 as a minimum.

5. Performance: **[Product test reports are required.]**

- a. Accuracy: Within 0.5 percent of measured flow over flow range from design flow to **[10]<Insert number>** percent of design flow.

- 1) Accuracy with 10 pipe diameters of straight pipe upstream and five pipe diameters downstream.
 - b. Repeatability: Within 0.2 percent over flow range.
 - c. Flow Range: 10 to 1 turndown.
 - d. Discharge Coefficient: Linear and stable throughout flow range.
 - e. Manufacturer to determine H/ID ratios to meet specified performance.
 - f. Pressure and Temperature: Suitable for system pressure and temperature.
 - g. Bidirectional Flow: Where required by application, sensor suitable for bidirectional flow measurement with no degradation of performance, with flow in either direction.
 - h. Size Range: **[NPS 1/2 through NPS 16 (DN 15 through DN 400)]<Insert pipe size range>**.
6. Construction:
- a. Body End Connections: Flanged[**or threaded (MNPT) for sizes NPS 1/2 through NPS 2 (DN 15 through DN 50)**].
 - 1) Flanges: Suitable for mating to ASME B16.5, Class 150 or 300 pipe flanges as required by system pressure; **[welding neck][raised faces]**; material to match body.
 - b. Body Material: **[Carbon steel][Type 304 stainless steel][or]** Type 316 or 316L stainless steel with ID to match adjacent pipe. Length is determined by manufacturer.
 - c. Wedge: Type 316 stainless steel segmented angled wedge equal on both sides.
 - d. Instrument Connections: **NPS 1/2 (DN 15)** FNPT using Class 3000 half couplings; material to match body.
 - e. Identification Tag: Stamped or engraved stainless steel.
7. Factory Calibration: Factory calibrate each sensor specific to application.
8. Flow Signal: Mate sensor in field to a pressure differential transmitter[**with high accuracy**] for flow measurement.
- E. Portable Meter Package for Liquid Flow Sensors:
1. Metal-reinforced-plastic carrying case.
 2. Waterproof meter with nominal **6-inch (150-mm)** round dial face.
 3. Meter with dual rupture-proof liquid-filled bellows having integral temperature compensation.
 4. Meter with external range and zero adjustment.
 5. Multiple meters in package, if required to accommodate flow sensors with a wide range of pressure signals.
 6. Two connecting hoses, **[10 ft. (3 m)]<Insert dimension>** long, with quick-connect couplings compatible with flow sensor couplings.
 7. Two brass, bronze, or stainless steel blowdown valves with Buna-N seals and blowdown hoses.
 8. Instruction book with flow versus pressure differential curves.
 9. Suitable for system working pressure and temperature.
 10. Portable meter package to connect to flow sensor without disturbing connection to pressure differential transmitter. Provide tees with isolation valves at flow signal connections to sensors.
 11. Turn over to Owner at Project completion.

2.9 STEAM FLOW SENSORS (PRIMARY ELEMENTS)

A. Averaging Pitot-Tube Steam Flow Sensors:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Armstrong International, Inc]
 - b. [Preso Meters; Badger Meter Inc.]
 - c. [Rosemount; Emerson Electric Co., Automation Solutions]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Armstrong International, Inc]
 - b. [Preso Meters; Badger Meter Inc.]
 - c. [Rosemount; Emerson Electric Co., Automation Solutions]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain all averaging pitot-tube steam flow sensors from a single manufacturer.
4. Standard: ASME MFC-12M.
5. Description:
 - a. Sensor cross-sectional shape to provide a flow separation at a fixed point independent of flow rate, pressure, or temperature with a stable flow coefficient maintained over a wide range of Reynolds numbers.
 - b. Sensor shape to promote less-turbulent zones on backside of sensor. Locate individual sensing ports in less-turbulent region to measure low pressure. Number of sensing ports is a function of pipe size.
 - c. Sensor high pressure measured by a frontal slot extending full length of sensor or a comparable design. Number of slots is a function of pipe size.
 - d. Manufacturer to submit on request independent testing documentation (product test reports), demonstrating compliance with specified performance.
 - e. Include sensor with flow signal isolation valves and connections that are suitable for connecting to a remote transmitter.
6. Performance:[**Product test reports are required.**]
 - a. Accuracy: Within [0.75]<Insert number> percent of measured flow over flow range from design flow to [10]<Insert number> percent of design flow.
 - b. Discharge Coefficient Factor: Within [0.75]<Insert number> percent of flow rate.
 - c. Repeatability: Within [0.1]<Insert number> percent.
 - d. Flow Range: [10][17]<Insert value> to 1 turndown.
 - e. Pressure and Temperature: Suitable for system pressure and temperature.
 - f. Pressure Drop: Up to [3]<Insert number> percent of full flow range pressure differential signal.
 - g. Pressure Differential Signal for Flow Measurement: Size orifice plates for approximately [100 inch wg (24.9 kPa)]<Insert pressure> pressure differential, except absolute value of meter range not to exceed absolute value of flowing pressure.
 - h. Size Range: [NPS 2 through NPS 48 (DN 50 through DN 1200)]<Insert pipe size range>.
7. Construction:
 - a. Sensor Surface Finish: Front surface textured for high-Reynolds-number applications if required to create a more turbulent boundary layer on front surface of sensor and produce

- a more predictable and repeatable separation of flow at edge of sensor.
- b. Sensor Material: Type 316 stainless steel.
- c. Packing Gland:
 - 1) Wetted Parts: Type 316 stainless steel.
 - 2) Packing Material: Graphite.
- d. Isolation Valve: Type 316 stainless steel full port ball valve configured to remove sensor while isolating process.
- e. Flanged In-line Pipe Spool:
 - 1) Factory mount sensor in a flanged section of pipe.
 - 2) Pipe material to match adjacent pipe.
 - 3) Flanges to match adjacent pipe.
- f. Flow Signal Connections: **NPS 1/2 (DN 15)** NPT with Type 316 stainless steel needle valves.
- g. Identification: Attach tag to each averaging pitot-tube sensor with a chain and label indicating pipe size, sensor series, sensor reading at flow rate, and pressure differential.
- 8. Factory Calibration: Factory calibrate each averaging pitot-tube sensor specific to application.
- 9. Flow Signal: Mate averaging pitot-tube sensor in field to a pressure differential transmitter[**with high accuracy**] for flow measurement.

B. Venturi Steam Flow Sensors:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[HCI; Hydronics Components Inc.]**
 - c. **[Preso Meters; Badger Meter Inc.]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[HCI; Hydronics Components Inc.]**
 - c. **[Preso Meters; Badger Meter Inc.]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain all venturi steam flow sensors from a single manufacturer.
- 4. On request, submit independent testing documentation (product test reports), demonstrating compliance with specified performance.
- 5. Standard: ASME MFC-3M.
- 6. Performance:
 - a. Accuracy: Within **[0.25][0.5]<Insert number>** percent of measured flow over flow range from design flow to **[10]<Insert number>** percent of design flow.
 - 1) Accuracy with **[five]<Insert number>** pipe diameters of straight pipe upstream and **[two]<Insert number>** pipe diameters downstream.

- b. Repeatability: Within **[0.1][0.2]<Insert number>** percent over the flow range.
- c. Beta Ratio: Select between 0.30 and 0.75 to achieve performance indicated. Match venturi with transmitter to provide performance of entire assembly.
- d. Flow Range: **[10]<Insert value>** to 1 turndown.
- e. Pressure and Temperature: Suitable for system pressure and temperature.
- f. Pressure Drop: Up to **[6][20]<Insert number>** percent of full flow range pressure differential signal.
- g. Pressure Differential Signal for Flow Measurement: Size orifice plates for approximately **[100 inch wg (24.9 kPa)]<Insert pressure>** pressure differential, except absolute value of meter range not to exceed absolute value of flowing pressure.
- h. Size Range: **[NPS 1/2 through NPS 48 (DN 15 through DN 1200)]<Insert pipe size range>**.

7. Construction:

- a. Body End Connections: Flanged[**or threaded (NPT) for sizes NPS 1/2 through NPS 2 (DN 15 through DN 50)**].
 - 1) Flanges: Suitable for mating to ASME B16.5 Class 150 or 300 pipe flanges as required by system pressure; **[welding neck][raised faces]**; material to match body.
 - b. Body Length: Length determined by manufacturer to comply with performance indicated.
 - c. Body Material: **[Carbon steel][or][Type 316 or 316L stainless steel]** with inside diameter to match adjacent pipe.
 - 1) Optional Materials: Option to use one-piece bronze or brass construction with threaded FNPT end connections for pipe sizes **NPS 1/2 through NPS 2 (DN 15 through DN 50)**.
 - d. Throat Material: Type 316 stainless steel.
 - e. Flow Signal Connections: Two accurately located built-in sensing taps, nipples, and shut-off valves for field connection to transmitter; minimum size **NPS 1/2 (DN 15) NPT**.
 - f. Identification: Attach tag to each venturi with a chain and label indicating pipe size, venturi series, station identification, and reading at flow rate and pressure differential.
8. Factory Calibration: Factory calibrate each venturi specific to application.
9. Flow Signal: Mate venturi in field to a pressure differential transmitter[**with high accuracy**] for flow measurement.

C. Orifice Plate Steam Flow Sensors:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Armstrong International, Inc]**
 - b. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Armstrong International, Inc]**
 - b. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - c. **[Spirax Sarco Limited]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all orifice plate steam flow sensors from a single manufacturer.
 4. Description: Concentric with sharp, square-edge orifice plate with handle and adjoining matching companion flanges[; **factory installed in a meter run**].
 5. Standards: ASME MFC-3M or ASME MFC-14M.
 6. Performance:
 - a. Accuracy: Within **[1][2][5]<Insert number>** percent of measured flow over flow range from design flow to **[10]<Insert number>** percent of design flow.
 - 1) Accuracy with **[10]<Insert number>** pipe diameters of straight pipe upstream and **[5]<Insert number>** pipe diameters downstream.
 - b. Repeatability: Within **[0.2]<Insert number>** percent over flow range.
 - c. Flow Range: **[5][10]<Insert value>** to 1 turndown.
 - d. Pressure and Temperature: Suitable for system pressure and temperature.
 - e. Pressure Drop: See Drawings.
 - f. Pressure Differential Signal for Flow Measurement: Size orifice plates for approximately **[100 inch wg (24.9 kPa)]<Insert pressure>** pressure differential, except absolute value of meter range not to exceed absolute value of flowing pressure.
 - g. Beta Ratio: Select ratio of orifice diameter to actual internal pipe diameter d/B (beta) between 0.30 and 0.70.
 - h. Size Range: **[NPS 1/2 through NPS 24 (DN 15 through DN 600)]<Insert pipe size range>**.
 7. Construction:
 - a. End Connections: Matching companion flanges suitable for mating to ASME B16.5, Class 150 or 300 pipe flanges as required by system pressure. **[Flanges with welding neck][Flanges with welding neck and raised faces]**.
 - b. Material: Fabricate orifice plate and matching companion flanges of **[Type 316 stainless steel][or]<Insert material>**.
 - c. Flow Signal Connections: **NPS 1/2 (DN 15) NPT**.
 - d. Identification: Stamp orifice plates with number and orifice bore on handle of orifice plate.
 8. Calibration: Include information and calculations for each orifice plate, showing compliance with ASME MFC-3M or ASME MFC-14M.
 9. Flow Signal: Mate orifice plate assembly in field to a pressure differential transmitter[**with high accuracy**] for flow measurement.
- D. Segmented-Wedge Steam Flow Sensors:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Armstrong International, Inc]**
 - b. **[Preso Meters; Badger Meter Inc.]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Armstrong International, Inc]**
 - b. **[Preso Meters; Badger Meter Inc.]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all segmented-wedge steam flow sensors from a single manufacturer.
 4. Description: Pressure differential design using a segmented or segmental wedge installed in a straight section of pipe. Design sensors for solids and particulates to be swept through the opening and for measurements with Reynolds Numbers down to 500 as a minimum.
 5. Performance: **[Product test reports are required.]**
 - a. Accuracy: Within 0.5 percent of measured flow over flow range from design flow to **[10]<Insert number>** percent of design flow.
 - 1) Accuracy with 10 pipe diameters of straight pipe upstream and five pipe diameters downstream.
 - b. Repeatability: Within 0.2 percent over flow range.
 - c. Flow Range: 10 to 1 turndown.
 - d. Discharge Coefficient: Linear and stable throughout flow range.
 - e. Manufacturer to determine H/ID ratios to meet specified performance.
 - f. Pressure and Temperature: Suitable for system pressure and temperature.
 - g. Bidirectional Flow: Where required by application, sensor suitable for bidirectional flow measurement with no degradation of performance, with flow in either direction.
 - h. Size Range: **[NPS 1/2 through NPS 16 (DN 15 through DN 400)]<Insert pipe size range>**.
 6. Construction:
 - a. Body End Connections: Flanged **[or threaded (MNPT) for sizes NPS 1/2 through NPS 2 (DN 15 through DN 50)]**.
 - 1) Flanges: Suitable for mating to ASME B16.5, Class 150 or 300 pipe flanges as required by system pressure; **[welding neck][raised faces]**; material to match body.
 - b. Body Material: **[Carbon steel][Type 304 stainless steel][or][Type 316 or 316L stainless steel]** with ID to match adjacent pipe. Length is to be determined by manufacturer.
 - c. Wedge: Type 316 stainless steel segmented angled wedge equal on both sides.
 - d. Instrument Connections: **NPS 1/2 (DN 15)** FNPT using Class 3000 half couplings; material to match body.
 - e. Identification Tag: Stamped or engraved stainless steel.
 7. Factory Calibration: Factory calibrate each sensor specific to application.
 8. Flow Signal: Mate sensor in field to a pressure differential transmitter **[with high accuracy]** for flow measurement.
- E. Portable Meter Package for Steam Flow Sensors:
1. Metal-reinforced-plastic carrying case.
 2. Waterproof meter with nominal **6-inch (150-mm)** round dial face.
 3. Meter with dual rupture-proof liquid-filled bellows having integral temperature compensation.
 4. Meter with external range and zero adjustment.
 5. Multiple meters in package, if required to accommodate flow sensors with a wide range of

- pressure signals.
6. Two connecting hoses, **[10 ft. (3 m)]<Insert dimension>** long, with quick-connect couplings compatible with flow sensor couplings.
 7. Two brass, bronze, or stainless steel blowdown valves with Buna-N seals and blowdown hoses.
 8. Instruction book with flow versus pressure differential curves.
 9. Suitable for system working pressure and temperature.
 10. Portable meter package to connect to flow sensor without disturbing connection to pressure differential transmitter. Provide tees with isolation valves at flow signal connections to sensors.
 11. Turn over to Owner at Project completion.

2.10 LIQUID FLOW SWITCHES

A. Liquid Flow Switch (Bellows Type):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Johnson Controls, Inc.]**
 - b. **[Penn Controls]**
 - c. **[W.E. Anderson; a division of Dwyer Instruments, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johnson Controls, Inc.]**
 - b. **[Penn Controls]**
 - c. **[W.E. Anderson; a division of Dwyer Instruments, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all bellows-type liquid flow switches from a single manufacturer.
4. Description:
 - a. Field-adjustable four-vane combinations.
 - b. Field-adjustable set-point adjustment screw.
 - c. Suitable for pipe sizes **NPS 1 through NPS 8 (DN 25 through DN 200)**.
 - d. Switch mounted vertically in horizontal pipe.
5. Performance:
 - a. Flow Rate Actuation and De-actuation: Varies with vane combination and set-point adjustment.
 - b. Pressure Limit: **[145 psig (1000 kPa)]<Insert pressure>**.
 - c. Temperature Limit: **[230 deg F (110 deg C)]<Insert temperature>**.
 - d. Electrical Rating: **[10 A resistive, 3 A conductive at 250 V ac]<Insert electrical rating>**.
 - e. Switch Type: **[SPDT]<Insert switch type>** snap switch.
6. Wetted Parts Construction:
 - a. Bellows: Tin-bronze.
 - b. Vanes: Stainless steel.
 - c. Body: Forged brass.

d. Process Connection: **[NPS 1 (DN 25)]<Insert pipe size>**.

7. Enclosure:

- a. Material: Die-cast aluminum alloy.
- b. Rating: NEMA 250, Type 4.
- c. Electrical Connection: Cable gland with attached wire leads.

B. Liquid Flow Switch (Magnetic Type):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. **[W.E. Anderson; a division of Dwyer Instruments, Inc.]**
- b. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[W.E. Anderson; a division of Dwyer Instruments, Inc.]**
- b. **<Insert manufacturer's name>**

3. Description:

- a. Field-adjustable five-vane combinations.
- b. Suitable for pipe sizes **NPS 1-1/2 through NPS 20 (DN 40 to DN 500)**.
- c. Mounting Suitable for Application: Switch vertically mounted in horizontal pipe, or switch horizontally mounted in vertical pipe with flow up.
- d. Listed and labeled as defined in NFPA 70, by a qualified testing agency[, **and marked for hazardous-environment Class I, Groups C, and D; Class II, Groups E, F, and G**].

4. Performance:

- a. Flow Rate Actuation and De-actuation: Varies with vane combination.
- b. Pressure Limit: **[1000 psig (6895 kPa) for brass][and][2000 psig (13 790 kPa) for Type 316 stainless steel]<Insert pressure>** body.
- c. Temperature Range: **[Minus 4 to plus 275 deg F (Minus 20 to plus 135 deg C)]<Insert temperature range>**.
- d. Electrical Rating: **[10 A at 125/250 V ac]<Insert electrical rating>**.
- e. Switch Type: **[SPDT][or][DPDT]** snap switch.

5. Wetted Parts Construction:

- a. Vanes: Type 316 stainless steel.
- b. Body: **[Brass][or][Type 316 stainless steel]**.
- c. Magnetic Keeper: **[Type 430 stainless steel][or][Type 316 stainless steel]**.
- d. Process Connection: **[NPS 1-1/2 (DN 40)]<Insert pipe size>**.

6. Enclosure:

- a. Material: Die-cast aluminum alloy.
- b. Threaded cover.

- c. Rating: NEMA 250, Type 4.
 - d. Electrical Connection: Labeled terminal block.
 - e. Conduit Connection: [3/4-inch (21-mm)]<Insert size> trade size.
- C. Liquid Flow Switch (Magnetic Type) for Small-Diameter Pipe:
- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [W.E. Anderson; a division of Dwyer Instruments, Inc.]
 - b. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [W.E. Anderson; a division of Dwyer Instruments, Inc.]
 - b. <Insert manufacturer's name>
 - 3. Description:
 - a. Suitable for pipe sizes [NPS 1/2 through NPS 1-1/4 (DN 15 through DN 32)][NPS 1/2 through NPS 2 (DN 15 through DN 50)]<Insert pipe size range>.
 - b. Mounting Suitable for Application: Switch vertically mounted in horizontal pipe, or switch horizontally mounted in vertical pipe with flow up.
 - c. Listed and labeled as defined in NFPA 70, by a qualified testing agency[, and marked for hazardous-environment Class I, Groups A, B, C, and D; Class II, Groups E, F, and G].
 - 4. Performance:
 - a. Flow Rate Actuation and De-actuation: Not adjustable.
 - b. Pressure Limit of Body: [1000 psig (6895 kPa) for brass][and][2000 psig (13 790 kPa) for Type 303 stainless steel]<Insert pressure>.
 - c. Pressure Limit of Tee: [250 psig (1724 kPa) for brass][1000 psig (6895 kPa) for malleable iron][and][2000 psig (13 790 kPa) for forged carbon steel and stainless steel]<Insert pressure>.
 - d. Temperature Range: [Minus 4 to plus 220 deg F (Minus 20 to plus 104 deg C)]<Insert temperature range>.
 - e. Electrical Rating: [5 A at 125/250 V ac]<Insert electrical rating>.
 - f. Switch Type: [SPDT][or][DPDT] snap switch.
 - 5. Wetted Parts Construction (Lower Body):
 - a. Vanes: Type 301 stainless steel.
 - b. Body Material: [Brass][or][Type 303 stainless steel].
 - c. Magnet: [Ceramic]<Insert material>.
 - d. Process Connection: [NPS 1/2 (DN 15)]<Insert pipe size>.
 - 6. Enclosure (Upper Body):
 - a. Material: [Brass][or][Type 303 stainless steel].
 - b. Rating: NEMA 250, Type 4.
 - c. Electrical Connection: Labeled terminal block.
 - d. Conduit Connection: [3/4-inch (21-mm)]<Insert size> trade size.

7. Integral Mounting Tee Furnished with Switch:

- a. Material: **[Brass][Forged carbon steel][Malleable iron][or][stainless steel]**.
- b. Size: **[Match adjacent pipe]<Insert size>**.
- c. Connection: Threaded pipe.

2.11 LIQUID FLOW TRANSMITTERS

A. Pressure Differential Transmitters with High Accuracy for Liquid Flow Measurement:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **<Insert manufacturer's name>**
- 3. For Applications in Hazardous Environments:
 - a. FM Approved for hazardous environments.
 - b. Intrinsically safe for Classes I, II, and III; Divisions 1 and 2; and Groups A through H.
 - c. Explosion-proof for Class I, Division 1, Groups B, C, and D.
 - d. Dust-ignition-proof for Class II, Division 1, Groups E, F, and G.
 - e. Dust-ignition-proof for Class III, Division 1.
- 4. Performance:
 - a. Pressure Range: **[Minus 250 to plus 250 inches wg (Minus 62.5 to plus 62.5 kPa)]<Insert pressure range>**.
 - b. Span: Field adjustable.
 - c. Minimum Span: **[2.5 inches wg (500 Pa)]<Insert pressure>**.
 - d. Accuracy: Within **[0.07]<Insert number>** percent of span or better.
 - e. Stability: Within **[0.125]<Insert number>** percent of upper range limit for **[5]<Insert value>** years.
 - f. Overpressure Limits: **[3626 psig (25 000 kPa)]<Insert pressure>**.
 - g. Ambient Temperature Limits: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>**.
 - h. Process Temperature Limits: **[Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)]<Insert temperature range>**.
 - i. Temperature Effect: Within **[0.025]<Insert number>** percent of upper range limit plus **[0.125]<Insert number>** percent of span.
 - j. Shock and vibration tolerant without impacting performance.
- 5. Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA dc current source.

- b. Signal capable of operating into [1000]<Insert value>-ohm load.
 - c. Digital signal based on HART protocol carried with current signal.
 - d. Dampening: Field-selectable zero to [30]<Insert value> seconds.
- 6. Operator Interface: Zero and span adjustments located behind removable cover.
- 7. Display: Five-digit, two-line digital display with minimum **0.4-inch- (10-mm-)** high alphanumeric characters.
- 8. Construction:
 - a. Enclosure: NEMA 250, Type 4X with removable cover on each side.
 - b. Nonwetted Parts: Aluminum or stainless steel.
 - c. Wetted Parts: Type 316 stainless steel.
 - d. Process Connections: **[NPS 1/2 (DN 15)]<Insert pipe size>**.
 - e. Drain/vent valve on low- and high-pressure connections.
 - f. Conduit Connections: Two **1/2-inch (16-mm)** trade-size conduit connections with plugs on side of instrument enclosure.
 - g. Wiring Connections: Labeled screw terminal block.
 - h. Mounting: Include mounting brackets suitable for installation.
- 9. Valve Manifold:
 - a. Furnish each transmitter with integrally mounted five-valve manifold.
 - b. Construction: Type 316 stainless steel.
 - c. Process Connections: **NPS 1/2 (DN 15)**.

B. Pressure Differential Transmitters for Liquid Flow Measurement:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Dwyer Instruments, Inc]**
 - b. **[Setra Systems Inc.]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **[Setra Systems Inc.]**
 - c. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain all pressure differential transmitters for liquid flow measurement from a single manufacturer.
- 4. Performance:
 - a. Range: **[Approximately 2 times set point]<Insert range>**.
 - b. Span: Adjustable; **[plus or minus 1 mA, non-interactive]<Insert range>**.
 - c. Accuracy: Within **[0.25]<Insert number>** percent of full scale.
 - d. Maximum Operating Pressure: Suitable for system pressure; not less than **[2.5]<Insert value>** times range.
 - e. Temperature Limits: **[0 to 175 deg F (Minus 18 to plus 79 deg C)]<Insert temperature range>**.
 - f. Compensation Temperature Limits: **[30 to 150 deg F (Minus 1 to plus 66 deg C)]<Insert**

- temperature range>.**
 - g. Thermal Effects: [0.02]<Insert number> percent of full scale per deg F (deg C).
 - h. Response Time: 30 to 50 ms.
 - i. Shock and vibration tolerant without impacting performance.
 - 5. Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA or zero to 10 V dc current source.
 - b. Signal capable of operating into [1000]<Insert value>-ohm load.
 - 6. Operator Interface:
 - a. Zero and span adjustments located behind removable cover.
 - b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.
 - 7. Construction:
 - a. Enclosure: NEMA 250, Type 4 or 4X; aluminum and stainless steel with removable cover.
 - b. Process Connections: [NPS 1/4 (DN 8)]<Insert pipe size>.
 - c. Conduit Connections: Knock out for 1/2-inch (15-mm) trade-size conduit connection on side of enclosure.
 - d. Wire Connections: Labeled screw terminal block.
 - e. Wetted Parts: 17-4 PH or 300 series stainless steel.
 - f. Mounting: Include mounting brackets suitable for installation.
 - 8. Valve Manifolds:
 - a. Include [three][or][five]-valve manifold with each transmitter.
 - b. Construction: Brass, bronze, or stainless steel.
 - c. Process Connections: [NPS 1/4 (DN 8)]<Insert pipe size>.

2.12 STEAM FLOW TRANSMITTERS

- A. Pressure Differential Transmitters with High Accuracy for Steam Flow Measurement:
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Rosemount; Emerson Electric Co., Automation Solutions]
 - b. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Rosemount; Emerson Electric Co., Automation Solutions]
 - b. <Insert manufacturer's name>
 - 3. For Applications in Hazardous Environments:

- a. FM Approved for hazardous environments.
 - b. Intrinsically safe for Classes I, II, and III; Divisions 1 and 2; and Groups A through H.
 - c. Explosion-proof for Class I, Division 1, Groups B, C, and D.
 - d. Dust-ignition-proof for Class II, Division 1, Groups E, F, and G.
 - e. Dust-ignition-proof for Class III, Division 1.
4. Performance:
- a. Pressure Range: **[Minus 250 to plus 250 inches wg (Minus 62.5 to plus 62.5 kPa)]<Insert pressure range>**.
 - b. Span: Field adjustable.
 - c. Minimum Span: **[2.5 inches wg (500 Pa)]<Insert pressure>**.
 - d. Accuracy: Within **[0.07]<Insert number>** percent of span or better.
 - e. Stability: Within **[0.125]<Insert number>** percent of upper range limit for **[5]<Insert value>** years.
 - f. Overpressure Limits: **[3626 psig (25 000 kPa)]<Insert pressure>**.
 - g. Ambient Temperature Limits: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>**.
 - h. Process Temperature Limits: **[Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)]<Insert temperature range>**.
 - i. Temperature Effect: Within **[0.025]<Insert number>** percent of upper range limit plus **[0.125]<Insert number>** percent of span.
 - j. Shock and vibration tolerant without impacting performance.
5. Analog Output Current Signal:
- a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into **[1000]<Insert value>**-ohm load.
 - c. Digital signal based on HART protocol carried with current signal.
 - d. Dampening: Field-selectable zero to **[30]<Insert value>** seconds.
6. Operator Interface: Zero and span adjustments located behind removable cover.
7. Display: Five-digit, two-line digital display with minimum **0.4-inch- (10-mm-)** high alphanumeric characters.
8. Construction:
- a. Enclosure: NEMA 250, Type 4X with removable cover on each side.
 - b. Nonwetted Parts: Aluminum or stainless steel.
 - c. Wetted Parts: Type 316 stainless steel.
 - d. Process Connections: **[NPS 1/2 (DN 15)]<Insert pipe size>**.
 - e. Drain/vent valve on low- and high-pressure connections.
 - f. Conduit Connections: **Two 1/2-inch (16-mm)** trade-size conduit connections with plugs on side of instrument enclosure.
 - g. Wiring Connections: Labeled screw terminal block.
 - h. Mounting: Include mounting brackets suitable for installation.
9. Valve Manifold:
- a. Furnish each transmitter with integrally mounted five-valve manifold.
 - b. Construction: Type 316 stainless steel.
 - c. Process Connections: **NPS 1/2 (DN 15)**.

B. Pressure Differential Transmitters for Steam Flow Measurement:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Dwyer Instruments, Inc]
 - b. [Setra Systems Inc.]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Dwyer Instruments, Inc]
 - b. [Setra Systems Inc.]
 - c. <Insert manufacturer's name>
3. Source Limitations: Obtain all liquid pressure differential transmitters for flow measurement from a single manufacturer.
4. Performance:
 - a. Range: [Approximately 2 times set point]<Insert range>.
 - b. Span: Field adjustable; [plus or minus 1 mA, non-interactive]<Insert range>.
 - c. Accuracy: Within [0.25]<Insert number> percent of full scale.
 - d. Maximum Operating Pressure: Suitable for system pressure; not less than [2.5]<Insert value> times range.
 - e. Temperature Limits: [0 to 175 deg F (Minus 18 to plus 79 deg C)]<Insert temperature range>.
 - f. Compensation Temperature Limits: [30 to 150 deg F (Minus 1 to plus 66 deg C)]<Insert temperature range>.
 - g. Thermal Effects: [0.02]<Insert number> percent of full scale per deg F (deg C).
 - h. Response Time: 30 to 50 ms.
 - i. Shock and vibration tolerant without impacting performance.
5. Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA or zero to 10 V dc current source.
 - b. Signal capable of operating into [1000]<Insert value>-ohm load.
6. Operator Interface:
 - a. Zero and span adjustments located behind removable cover.
 - b. Bleed screws on side of body - two screws on low-pressure side, and one screw on high-pressure side - for air in line and pressure cavity.
7. Construction:
 - a. Enclosure: NEMA 250, Type 4 or 4X; aluminum and stainless steel with removable cover.
 - b. Process Connections: [NPS 1/4 (DN 8)]<Insert pipe size>.
 - c. Conduit Connections: Knock out for 1/2-inch (15-mm) trade-size conduit connection on side of enclosure.
 - d. Wire Connections: Labeled screw terminal block.
 - e. Wetted Parts: 17-4 PH or 300 series stainless steel.
 - f. Mounting: Include mounting brackets suitable for installation.
8. Valve Manifolds:

- a. Include **[three][or][five]**-valve manifold with each transmitter.
- b. Construction: Brass, bronze, or stainless steel.
- c. Process Connections: **[NPS 1/4 (DN 8)]<Insert pipe size>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
 - 1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on Shop Drawings.
 - 2. Do not begin installation without submittal approval of mounting location.
- E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.
- F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTRUMENT APPLICATIONS

- A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
- B. Thermal Airflow-Measurement Stations:
 - 1. For Ducts/Plenums: **[All applications]<Insert applications>**.
 - 2. For Small Ducts/Plenums: **[All applications]<Insert applications>**.
 - 3. For Fan Arrays: **[All applications]<Insert applications>**.
 - 4. For Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans: **[All applications]<Insert applications>**.
 - 5. For Air Terminal Units: **[All applications]<Insert applications>**.
 - 6. For Packaged HVAC Units: **[All applications]<Insert applications>**.
 - 7. For Data Center Server Rack Airflow/Pressure and Temperature Monitoring: **[All applications]<Insert applications>**.
- C. Velocity Pressure Duct-Mounted Airflow Sensors:
 - 1. Measured Velocities Greater Than 500 fpm (2.5 m/s): **[Velocity pressure pitot-tube airflow sensor stations for duct applications][Velocity pressure probe-type airflow sensor stations**

for duct applications][velocity pressure probe-type airflow sensors for duct applications].

D. Fan-Mounted Airflow Sensors:

1. Measured Velocities Greater Than 500 fpm (2.5 m/s): [Velocity pressure probe-type fan inlet airflow traverse sensors][Piezometer ring fan inlet airflow sensor].

E. Outdoor Airflow Measurement: [Outdoor airflow-measurement system using differential static pressure][Thermal airflow-measurement stations].

F. Airflow Switches:

1. Measured Velocities 400 fpm (2.0 m/s) and Less: Polymer film sail switch.
2. Measured Velocities Greater than 400 fpm (2.0 m/s): Stainless steel single-vane switch.

G. Airflow Transmitters for Use with Velocity Pressure-Type Sensors:

1. Exhaust Air Airflow: [Airflow transmitter with 0.10 percent accuracy and auto-zero feature][Airflow transmitter with 0.25 percent accuracy and auto-zero feature][Pressure differential transmitter for airflow measurement][Pressure differential indicating transmitter, switch, and controller for airflow measurement].
2. Outdoor Air Airflow: [Airflow transmitter with 0.10 percent accuracy and auto-zero feature][Airflow transmitter with 0.25 percent accuracy and auto-zero feature][Pressure differential transmitter for airflow measurement][Pressure differential indicating transmitter, switch, and controller for airflow measurement].
3. Return Air Airflow: [Airflow transmitter with 0.10 percent accuracy and auto-zero feature][Airflow transmitter with 0.25 percent accuracy and auto-zero feature][Pressure differential transmitter for airflow measurement][Pressure differential indicating transmitter, switch, and controller for airflow measurement].
4. Supply Air Airflow: [Airflow transmitter with 0.10 percent accuracy and auto-zero feature][Airflow transmitter with 0.25 percent accuracy and auto-zero feature][Pressure differential transmitter for airflow measurement][Pressure differential indicating transmitter, switch, and controller for airflow measurement].

H. Liquid Flow Sensors (Primary Elements):

1. Averaging Pitot Tubes: <Insert system><Insert unique application>.
2. Venturis: <Insert system><Insert unique application>.
3. Orifice Plates: <Insert system><Insert unique application>.
4. Segmented Wedge: <Insert system><Insert unique application>.

I. Steam Flow Sensors (Primary Elements):

1. Averaging Pitot Tubes: <Insert system><Insert unique application>.
2. Venturis: <Insert system><Insert unique application>.
3. Orifice Plates: <Insert system><Insert unique application>.
4. Segmented Wedge: <Insert system><Insert unique application>.

J. Liquid Flow Meters:

1. Insertion Impeller Flow Meters with Accuracy of One Percent of Full Scale: <Insert system><Insert unique application>.
2. Insertion Impeller Flow Meters with 0.5 Percent Accuracy: <Insert system><Insert unique application>.
3. Insertion Turbine Flow Meters: <Insert system><Insert unique application>.

4. In-Line Body Turbine Flow Meters: **<Insert system><Insert unique application>**.
5. In-Line Body Electromagnetic Flow Meters: **<Insert system><Insert unique application>**.
6. Insertion Electromagnetic Flow Meter: **<Insert system><Insert unique application>**.
7. In-Line Body Thermal Mass Flow Meters: **<Insert system><Insert unique application>**.
8. Vortex-Shedding Flow Meter with Integral Temperature Measurement: **<Insert system><Insert unique application>**.
9. Vortex-Shedding Flow Meter with Integral Pressure and Temperature Measurement: **<Insert system><Insert unique application>**.
10. Vortex-Shedding Flow Meter for Hazardous Environments: **<Insert system><Insert unique application>**.
11. Compact In-Line Body Ultrasonic Flow Meters: **<Insert system><Insert unique application>**.
12. Clamp-On Ultrasonic Flow Meters: **<Insert system><Insert unique application>**.

K. Steam Flow Meters:

1. Vortex-Shedding Flow Meter with Integral Temperature Measurement: **<Insert system><Insert unique application>**.
2. Vortex-Shedding Flow Meter with Integral Pressure and Temperature Measurement: **<Insert system><Insert unique application>**.
3. Vortex-Shedding Flow Meter for Hazardous Environments: **<Insert system><Insert unique application>**.

L. Liquid Flow Switches:

1. Bellows Type: **<Insert system><Insert unique application>**.
2. Magnetic Type: **<Insert system><Insert unique application>**.
3. Magnetic Type for Small Diameter Pipe: **<Insert system><Insert unique application>**.

M. Liquid Flow Transmitters:

1. Pressure Differential Transmitter with High Accuracy for Liquid Flow Measurement: **<Insert system><Insert unique application>**.
2. Pressure Differential Transmitter for Liquid Flow Measurement: **<Insert system><Insert unique application>**.

N. Steam Flow Transmitters:

1. Pressure Differential Transmitter with High Accuracy for Steam Flow Measurement: **<Insert system><Insert unique application>**.
2. Pressure Differential Transmitter for Steam Flow Measurement: **<Insert system><Insert unique application>**.

3.3 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a **<Insert lbf (kgf)>**.
- D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

- E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- F. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they will be subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
 - a. Laboratory exhaust airstreams.
 - b. Process exhaust airstreams.
 - c. **<Insert requirement>**.
 - 3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings with a corrosive-resistant coating that is suitable for environment.
 - 4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

- A. Mounting Location:
 - 1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
 - 2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
 - 3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 - 4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 - 5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
 - 6. Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of **[2][3]<Insert number>** percent.
 - 7. Install instruments in dry gas and non-condensable-vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of **[2][3]<Insert number>** percent.
- B. Mounting Height:
 - 1. Mount remote displays, switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of **42 to 72 inches (1050 to 1800 mm)** above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at **60 inches (1500 mm)**.

- C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.5 INSTALLATION OF FLOW INSTRUMENTS

A. Airflow Sensors and Stations:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Install sensors so they are accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to handle clean sensors.

B. Liquid and Steam Sensors:

1. Install sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.
3. Install pipe reducers for in-line sensors smaller than line size. Position reducers at distance from sensor to avoid interference and impact on accuracy.
4. Install in-line sensors with flanges or unions to provide drop-in and -out installation.
5. Isolation Without System Interruption: Where indicated, install isolation valves upstream and downstream of in-line sensors and a piping bypass, with isolation valve placed around the isolation valves to allow for sensor removal and replacement without system interruption.

C. Liquid and Steam Flow Meters:

1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.
3. Install in-line meters with flanges or unions to provide drop-in and -out installation.
4. Isolation Without System Interruption: Where indicated on Drawings, install isolation valves upstream and downstream of in-line meters and a piping bypass, with isolation valve placed around the isolation valves to allow for meter removal and replacement without system interruption.
5. Insertion Meters:
 - a. Install system process connections full size of meter connection and meter manufacturer requirements, but not less than **[NPS 1 (DN 25)][NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]<Insert pipe size>**. Provide **[stainless steel]**NPT threaded bushing if required by installation.
 - b. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
 - c. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.
6. Orifice Plates:
 - a. Meter run piping or tubing is to be uniform internal surface, which is free of internal grooves and striations, but is not polished. Out of roundness is not to exceed 0.5 percent. A reduction of the pipe diameter or distortion caused by welding is unacceptable.

- b. Locate orifice plates in horizontal or vertical piping following good metering practice.
- c. Maintain minimum upstream and downstream straight pipe to comply with ASME's "Fluid Meters: Their Theory and Application" and manufacturer requirements.

D. Liquid Switches:

- 1. Install system process connection full size of switch connection, but not less than **[NPS 1 (DN 25)][NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]**<Insert pipe size>. Install **[stainless steel]** bushing if required to mate switch to system connection.
- 2. Install switch in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
- 3. In applications where top-dead-center location is not possible due to field constraints, install switch at location along top half of pipe if switch is acceptable by manufacturer for mounting orientation.

E. Transmitters:

- 1. Install airflow transmitters serving an air system in a single location **[adjacent to][or][within]** system control panel.
- 2. Install liquid flow transmitters, not integral to sensors, in vicinity of sensor. Where multiple flow transmitters serving same system are located in same room, co-locate transmitters by system to provide service personnel a single and convenient location for inspection and service.

3.6 INSTALLATION OF ELECTRICAL POWER CONNECTIONS

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.7 INSTALLATION OF CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.

- B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.8 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification[**and on face of ceiling directly below instruments concealed above ceilings**].

3.9 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.10 CHECKOUT PROCEDURES

- A. Description:
 - 1. Check out installed products before continuity tests, leak tests, and calibration.
 - 2. Check instruments for proper location and accessibility.
 - 3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
 - 4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
- B. Flow Instrument Checkout:
 - 1. Verify that sensors are installed correctly with respect to flow direction.
 - 2. Verify that sensor attachment is properly secured and sealed.
 - 3. Verify that processing tubing attachment is secure and isolation valves have been provided.
 - 4. Inspect instrument tag against approved submittal.
 - 5. Verify that recommended upstream and downstream distances have been maintained.

3.11 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
 - 4. Equipment and procedures used for calibration are to meet instrument manufacturer's instructions.

5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments are to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent needs to be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11 in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values. **[Field calibration is not required for instruments that have been factory calibrated and provided with certificates.]**
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.12 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes **[three][six][nine][12]** months' full maintenance by **[skilled employees of systems and equipment Installer][manufacturer's authorized service representative]**. Include **[monthly][quarterly][semiannual][annual]** preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

3.13 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.



- C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 09 23 14



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 23 14	23 09 23 00	Direct Digital Control (DDC) System for HVAC
23 09 23 14	23 09 23 00a	Leak Detection Instruments
23 09 23 14	23 09 23 00b	Position Instruments
23 09 23 14	23 09 00 00	Speed Instruments
23 09 23 14	23 09 23 00c	Sequence of Operations for HVAC DDC



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 09 23 16 - GAS INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Carbon dioxide sensors and transmitters.
2. Carbon dioxide and VOC combination sensors and transmitters.
3. Carbon monoxide sensors and transmitters.
4. Carbon monoxide monitoring system, multipoint air sampling.
5. Oxygen monitoring system, single point continuous.
6. VOC sensors and transmitters.

B. Related Requirements:

1. Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, cable, and other requirements that relate to this Section.
2. Section 230923.27 "Temperature Instruments" for temperature sensors that combine gas detection into a single device.
3. Section 230993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 DEFINITIONS

- A. NDIR:** Nondispersive infrared.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Carbon dioxide sensors and transmitters,
2. Carbon dioxide and VOC combination sensors and transmitters.
3. Carbon monoxide sensors and transmitters.
4. Carbon monoxide monitoring system, multipoint air-sampling.
5. Oxygen monitoring system, single point continuous.
6. VOC sensors and transmitters.

B. Product Data Submittals: For each product.

1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Installation instructions, including factor affecting performance.
3. Product description with complete technical data, performance curves, product specification sheets.
4. Product data indicating ASHRAE 62.1 compliance.

- C. Shop Drawings:
 - 1. Plans, elevations, sections, and **[mounting]** details.
 - 2. Diagrams for power, signal, and control wiring.
 - 3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.
- D. Samples: For each exposed product installed in finished space.
- E. Sustainable Design Submittals:
 - 1. Product data showing compliance with ASHRAE 62.1.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation details, or BIM, drawn to scale, on which wall-mounted instruments located in finished space are shown and coordinated with each other, showing relationship to light switches, fire-alarm devices, and other installed devices using input from installers of items involved.
- B. Product Test Reports: For **[carbon dioxide sensors and transmitters,][combination carbon dioxide and VOC sensors and transmitters,][carbon monoxide sensors and transmitters,][multipoint air-sampling carbon monoxide monitoring system,][single-point oxygen monitoring system,][VOC sensors and transmitters,]** for tests performed by **[manufacturer and witnessed by a qualified testing agency][a qualified testing agency]**.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gas instruments.

PART 2 - PRODUCTS

2.1 CARBON DIOXIDE SENSORS AND TRANSMITTERS

- A. Carbon Dioxide Sensors and Transmitters, Duct Mounted:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - g. **[Vaisala]**
 - h. **[Veris Industries]**
 - i. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc.]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - g. **[Vaisala]**
 - h. **[Veris Industries]**
 - i. **<Insert manufacturer's name>**
 3. Source Limitations: Provide carbon dioxide sensors and transmitters, duct mounted, from single manufacturer.
 4. Description:
 - a. NDIR or equivalent technology that provides performance indicated, long-term stability, and reliability.
 5. Performance:
 - a. Air Velocity Range: **[0 to 2000 fpm (0 to 10.2 m/s)]<Insert flow velocity range>**.
 - b. Carbon Dioxide Concentration Range: Zero to **[2000]<Insert value>** ppm.
 - c. Accuracy: Within **[2][3]<Insert number>** percent of reading, plus or minus **[30]<Insert value>** ppm.
 - d. Repeatability: Within **[1]<Insert number>** percent of full scale.
 - e. Long-Term Stability: Within **[5]<Insert number>** percent of full scale after more than **[5]<Insert number>** years.
 - f. Response Time: Within **[60]<Insert number>** seconds.
 - g. Warm-up Time: Within **[1]<Insert number>** minute(s).
 - h. Ambient Relative Humidity: **[Zero to 85][Zero to 95]<Insert numbers>** percent noncondensing.
 - i. Ambient Temperature: **[23 to 113 deg F (minus 5 to plus 45 deg C)][or][32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.
 6. Output Signals:
 - a. Analog Output Signal: **[4 to 20 mA][or][zero to 10 V dc]<Insert signal>** output signal, linearized to carbon dioxide concentration in parts per million (ppm).
 - b. Digital Output Signal: **[SPST][or][SPDT]<Insert requirement>**.
 7. Serial Communication: **[BACnet MS/TP][or][Modbus RTU]<Insert signal>**.
 8. Construction:
 - a. Enclosure: Painted metal or plastic; equivalent to NEMA 250, **[Type 1][or][Type 4][Type 4X]<Insert type>**.
 - b. Electrical Connections: Screw terminals.
 - c. Visual Display: Equip with digital display for continuous indication of carbon dioxide concentration **[only where indicated on Drawings]**.
 9. Calibration Kit: Provide kit and turnover to Owner at start of warranty period.
- B. Carbon Dioxide Sensors and Transmitters, Wall Mounted:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Dwyer Instruments, Inc]**
 - d. **[Greystone Energy Systems, Inc.]**
 - e. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - f. **[Johnson Controls, Inc.]**
 - g. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - h. **[Vaisala]**
 - i. **[Veris Industries]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Dwyer Instruments, Inc]**
 - d. **[Greystone Energy Systems, Inc.]**
 - e. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - f. **[Johnson Controls, Inc.]**
 - g. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - h. **[Vaisala]**
 - i. **[Veris Industries]**
 - j. **<Insert manufacturer's name>**
3. Source Limitations: Provide carbon dioxide sensors and transmitters, wall mounted, from single manufacturer.
4. Description:
 - a. NDIR or equivalent technology that provides performance indicated, long-term stability, and reliability.
5. Performance:
 - a. Carbon Dioxide Concentration Range: Zero to **[2000]<Insert value>** ppm.
 - b. Accuracy: Within **[2]<Insert number>** percent of reading, plus or minus **[30]<Insert value>** ppm.
 - c. Repeatability: Within **[1]<Insert number>** percent of full scale.
 - d. Long-Term Stability: Within **[5]<Insert number>** percent of full scale after more than **[5]<Insert number>** years.
 - e. Response Time: Within **[60]<Insert number>** seconds.
 - f. Warm-up Time: Within **[5]<Insert number>** minutes.
 - g. Ambient Relative Humidity: **[Zero to 95]<Insert numbers>** percent noncondensing.
 - h. Ambient Temperature: **[32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.
6. Output Signals:
 - a. Analog Output Signal: **[4 to 20 mA][or][zero to 10 V dc]<Insert signal>** output signal, linearized to carbon dioxide concentration in parts per million (ppm).

- b. Digital Output Signal: [SPST][or][SPDT]<Insert requirement>.
- 7. Serial Communication: [BACnet MS/TP][or][Modbus RTU]<Insert signal>.
- 8. Construction:
 - a. Enclosure: White plastic; equivalent to NEMA 250, Type 1.
 - b. Electrical Connections: Screw terminals.
 - c. Visual Display: Equip with digital display for continuous indication of carbon dioxide concentration[**only where indicated on Drawings**].
- 9. Calibration Kit: Provide to Owner at start of warranty period.

2.2 CARBON DIOXIDE AND VOC COMBINATION SENSORS AND TRANSMITTERS

A. Carbon Dioxide and VOC Combination Sensors and Transmitters, Duct Mounted:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Belimo Aircontrols (USA), Inc]
 - b. [Dwyer Instruments, Inc]
 - c. [Siemens Industry, Inc., Building Technologies Division]
 - d. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Belimo Aircontrols (USA), Inc]
 - b. [Dwyer Instruments, Inc]
 - c. [Siemens Industry, Inc., Building Technologies Division]
 - d. <Insert manufacturer's name>
- 3. Source Limitations: Provide carbon dioxide and VOC combination sensors and transmitters, duct mounted, from single manufacturer.
- 4. Description:
 - a. Carbon Dioxide Measurement: NDIR or equivalent technology that provides performance indicated, long-term stability, and reliability.
 - b. VOC Measurement:
 - 1) Technology: [Metal-oxide semiconductor]<Insert type> or equivalent technology that provides performance, long-term stability, and reliability.
 - 2) Senses and responds to combined concentration of more than [30]<Insert number> contaminants commonly found in indoor environments.
- 5. Performance:
 - a. Carbon Dioxide Concentration Range: Zero to [2000]<Insert value> ppm.
 - b. Carbon Dioxide Accuracy: Within [40][50]<Insert value> ppm, plus [2][3]<number> percent of reading.
 - c. VOC Range: Zero to [2000]<Insert value> ppm correlated to carbon dioxide concentration.
 - d. VOC Sensitivity Ranges: Field selectable; low, normal, or high.

- e. Ambient Relative Humidity: **[Zero to 95][or][10 to 90]<Insert numbers>** percent noncondensing.
 - f. Ambient Temperature: **[32 to 122 deg F (0 to 50 deg C)][or][32 to 120 deg F (0 to 48 deg C)]<Insert temperature range>**.
6. Output Signal: **[4 to 20 mA][or][zero to 10 V dc]<Insert signal>**.
7. Construction:
- a. Enclosure: Painted metal or plastic; equivalent to NEMA 250, **[Type 1][or][Type 4][Type 4X]<Insert type>**.
 - b. Electrical Connections: Screw terminals.
 - c. Visual Display: Equip with digital display for continuous indication of carbon dioxide and VOC concentration **[only where indicated on Drawings]**.

B. Carbon Dioxide and VOC Combination Sensors and Transmitters, Wall Mounted:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Dwyer Instruments, Inc]**
 - b. **[Siemens Industry, Inc., Building Technologies Division]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Dwyer Instruments, Inc]**
 - b. **[Siemens Industry, Inc., Building Technologies Division]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Provide carbon dioxide and VOC combination sensors and transmitters, wall mounted, from single manufacturer.
4. Description:
- a. Carbon Dioxide Measurement: NDIR or equivalent technology that provides performance indicated, long-term stability, and reliability.
 - b. VOC Measurement:
 - 1) Technology: **[Metal-oxide semiconductor]<Insert type>** or equivalent technology that provides performance, long-term stability, and reliability.
 - 2) Senses and responds to combined concentration of more than **[30]<Insert number>** contaminants commonly found in indoor environments.
5. Performance:
- a. Carbon Dioxide Concentration Range: Zero to **[2000]<Insert value>** ppm.
 - b. Carbon Dioxide Accuracy: Within **[50]<Insert value>** ppm, plus **[2]<number>** percent measured value.
 - c. VOC Range: Zero to **[2000]<Insert value>** ppm correlated to carbon dioxide concentration.
 - d. VOC Sensitivity Ranges: Field selectable; low, normal, or high.
 - e. Ambient Relative Humidity: **[5 to 95]<Insert number>** percent noncondensing.
 - f. Ambient Temperature: **[32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.

6. Output Signals: **[4 to 20 mA][or][zero to 10 V dc]<Insert signal>**.
7. Construction:
 - a. Enclosure: White plastic; equivalent to NEMA 250, Type 1.
 - b. Electrical Connections: Screw terminals.
 - c. Visual Display: Equip with digital display for continuous indication of carbon dioxide and VOC concentration **[only where indicated on Drawings]**.

2.3 CARBON MONOXIDE SENSORS AND TRANSMITTERS

A. Carbon Monoxide Sensors and Transmitters, Duct Mounted:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell Analytics; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell Analytics; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **<Insert manufacturer's name>**
3. Description: Electrochemical measurement technology or equivalent technology that provides performance indicated, long-term stability, and reliability.
4. Performance:
 - a. Carbon Monoxide Concentration Range: Zero to **[100]<Insert value>** ppm.
 - b. Accuracy: Within **[3][5]<Insert number>** percent of full-scale range.
 - c. Repeatability: Within **[1]<Insert number>** percent of full scale.
 - d. Long-Term Stability: Within **[5]<Insert number>** percent of full scale per year.
 - e. Response Time: Within **[30]<Insert number>** seconds.
 - f. Warm-up Time: Within **[1]<Insert number>** minute(s).
 - g. Ambient Relative Humidity: **<Insert number>** percent noncondensing.
 - h. Ambient Temperature: **[Minus 4 to plus 122 deg F (Minus 16 to plus 50 deg C)]<Insert temperature range>**.
5. Output Signals:
 - a. Analog Output Signal: **[4 to 20 mA][or][zero to 10 V dc]<Insert signal>**.
 - b. Digital Output Signal: **[SPST][or][SPDT]<Insert requirement>**.
6. Serial Communication: **[BACnet MS/TP][or][Modbus RTU]<Insert signal>**.

7. Construction:
 - a. Enclosure: Painted metal or plastic; equivalent to NEMA 250, **[Type 1][or][Type 4][Type 4X]<Insert type>**.
 - b. Electrical Connections: Screw terminals.
 - c. Visual Display: Equip with digital display for continuous indication of carbon dioxide concentration **[only where indicated on Drawings]**.

8. Calibration Kit: Provide and turn over to Owner at start of warranty period.

B. Carbon Monoxide Sensors and Transmitters, Wall Mounted:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell Analytics; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[MSA Safety, Inc.]**
 - g. **[Veris Industries]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell Analytics; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[MSA Safety, Inc.]**
 - g. **[Veris Industries]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Provide carbon monoxide sensors and transmitters, wall mounted, from single manufacturer.
4. Description: Electrochemical measurement technology or equivalent technology that provides performance indicated, long-term stability, and reliability.
 - a. Individual Sensor/Transmitter Applications: Each sensor/transmitter connected directly to DDC system.
 - b. Multiple Sensor/Transmitters for Zoned Applications: Multiple sensor/transmitters arranged in zones as indicated on Drawings and directly connected to carbon monoxide monitoring system controller; furnished with sensors and transmitters as part of a complete system furnished by single manufacturer.
5. Performance:
 - a. Carbon Monoxide Concentration Range: Zero to **[100]<Insert value>** ppm.
 - b. Accuracy: Within **[5]<Insert number>** percent of full-scale range.

- c. Repeatability: Within [1]<Insert number> percent of full scale.
 - d. Long-Term Stability: Within [5]<Insert number> percent of full scale after more than [5]<Insert number> years.
 - e. Response Time: Within [30]<Insert number> seconds.
 - f. Warm-up Time: Within [1]<Insert number> minute(s).
 - g. Ambient Relative Humidity: <Insert number> percent noncondensing.
 - h. Ambient Temperature: [Minus 4 to plus 122 deg F (Minus 20 to plus 50 deg C)]<Insert temperature range>.
6. Sensor and Transmitter Output Signals:
- a. Analog Output Signal: [4 to 20 mA][or][zero to 10 V dc]<Insert signal>.
 - b. Digital Output Signal: [SPDT]<Insert requirement>.
7. Sensor and Transmitter Serial Communication: [BACnet MS/TP][or][Modbus RTU].
8. Sensor and Transmitter Construction:
- a. Enclosure: Painted metal or plastic; equivalent to NEMA 250, [Type 1][or][Type 4][Type 4X]<Insert type>.
 - b. Electrical Connections: Screw terminals.
 - c. Visual Display: Equip with digital display for continuous indication of carbon dioxide concentration[only where indicated on Drawings].
9. Carbon Monoxide System Controller:
- a. Configuration:
 - 1) Quantity of Sensors Connected to Each Controller: See Drawings.
 - 2) Arrangement and Quantity of Zones per Controller: See Drawings.
 - b. Signals:
 - 1) Sensor Signal to Controller: [Analog][or][BACnet MS/TP][Modbus RTU][See Drawings].
 - 2) Controller Output Signal: [Analog][Digital signal, through control relays, for each sensor connected to controller to indicated alarm status,][BACnet MS/TP][or][Modbus RTU][See Drawings].
 - c. Enclosure: Painted metal or plastic; equivalent to NEMA 250, [Type 1][or][Type 4][Type 4X]<Insert type>.
 - d. Electrical Connections: Screw terminals.
 - e. Operator Interface: Keypad or touch sensitive digital display, located on front of enclosure; access protected by password.
 - f. Visual Display: Multiple lines, backlit LCD.
 - g. Alarms:
 - 1) Audible Alarm: Audible alarm with local silence reset; <Insert sound level>.
 - 2) Visual Alarms: Faults or failures, individual sensor readings in alarm.
10. Calibration Kit: Provide kit and turn over to Owner at start of warranty period.

2.4 CARBON MONOXIDE MONITORING SYSTEM, MULTIPOINT AIR SAMPLING

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be

incorporated into the Work include, but are not limited to, the following]:

1. [ACI Automation; Automation Components Inc]
 2. [MSA Safety, Inc.]
 3. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [ACI Automation; Automation Components Inc]
 2. [MSA Safety, Inc.]
 3. <Insert manufacturer's name>
- C. Source Limitations: Provide carbon monoxide monitoring system, multipoint air sampling, from single manufacturer.
- D. Description: Multipoint air-sampling system with integral air-sampling pumps, gas analyzer(s), and microprocessor.
1. System Sampling Point Quantity: [8][16][24][32][See Drawings]<Insert quantity>.
 2. Monitors and reports carbon monoxide concentration level, warnings, and alarms for each sampling point, system operation failures, and faults.
 3. Each sampling point is to be individually piped in field to external connection on monitoring system enclosure.
- E. Performance:
1. Concentration Range: Zero to [100]<Insert value> ppm.
 2. Accuracy: Within [5]<Insert number> percent of full-scale range.
 3. Repeatability: Within [1]<Insert number> percent of full scale.
 4. Long-Term Stability: Within [5]<Insert number> percent of full scale after more than [5]<Insert number> years.
 5. Sampling Rate: Within [10]<Insert number> seconds; adjustable in 1 second increments from zero to [5]<Insert number> minutes.
 6. Response Time: Within [10]<Insert number> seconds.
 7. Warm-up Time: Within [1]<Insert number> minute(s).
 8. Ambient Relative Humidity: [5 to 90]<Insert number> percent noncondensing.
 9. Ambient Temperature: [32 to 95 deg F (0 to 35 deg C)]<Insert temperature range>.
 10. Air Sample Temperature: [0 to 140 deg F (Minus 17 to plus 60 deg C)]<Insert temperature range>.
 11. Zero and Span Drift: Within [1]<Insert number> percent of full scale within a [24]<Insert number>-hour period.
- F. Analyzer:
1. [Single][Two][Three][Four] analyzer(s) arranged for discrete gas measurement across all sampling points.
 2. Analyzer Technology: [Electrochemical]<Insert type> or equivalent technology that provides performance indicated, long-term stability, and reliability.
 3. Temperature-compensate readings over operating range as required by performance.
- G. Control and Display:
1. Backlight alphanumeric visual display and operator interface located on face of enclosure.
 2. Visual indication for sample analyzing, sample concentration, sample high-concentration alarm,

- analyzer malfunction, flow failure, and calibration.
 3. Operator configurable order of sample points.
 4. Each sample point is capable of being manually sampled through an override feature.
 5. System data with internal battery backup for at least an **[two years]<Insert time>**.
 6. Security: Password-protected system parameters.
- H. Network Communication Interface: **[BACnet IP][or][Modbus TCP]**.
- I. Output Signals:
1. Analog Output Signals: **[4 to 20 mA][or][zero to 10 V dc]<Insert signal>** signal for each sample point; proportional with gas concentration.
 2. Digital Output Signals: Operator-configurable, **[SPDT]<Insert requirement>** control relays, one for each sample point alarm **[and fault]**.
- J. Enclosure:
1. NEMA 250, **[Type 1]<Insert type>**.
 2. Hinged **[and locking]** door, full size of front face.
 3. Size enclosure to house all system components. Multiple adjoining enclosures are acceptable if interconnected and joined to a common support structure.
- K. Filters: Provide each air-sampling point with a 0.3-micron filter located **[at sampling point air inlet][or][inline at enclosure]**.
- L. Air-Sampling Pump: Dual-head diaphragm pump draws an air sample from each sampling point through field-installed tubing, and a microprocessor-controlled sequencer feeds the air sample to an analyzer(s) with a new sample at the frequency (sample rate) indicated.
- M. Calibration Equipment:
1. Span and zero calibration automatically initiated by microprocessor.
 2. Operator is to be also able to manually initiate span and zero calibration through operator interface.
 3. Provide equipment necessary to automatically and manually calibrate the system, including, but not be limited to, the following:
 - a. Regulator assemblies.
 - b. Zero cap.
 - c. Calibration cap.
 - d. Two cylinders filled with calibration gas.
- N. Manufacturer Startup: Final adjustment; calibration, testing, and startup of system is performed by a trained manufacturer representative.
- 2.5 OXYGEN MONITORING SYSTEM, SINGLE POINT CONTINUOUS
- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[MSA Safety, Inc.]**
 2. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's**

name; product name or designation> or comparable product by one of the following:

1. **[MSA Safety, Inc.]**
2. **<Insert manufacturer's name>**

C. Source Limitations: Provide oxygen monitoring system, single point continuous, from single manufacturer.

D. Description:

1. System measures and displays a single gas concentration, provides local audio and visual alarms when preset limits are exceeded, and send output signals of gas concentration and detected alarms.
2. System requires no periodic maintenance other than periodic checking of sensor response to a known concentration of gas.
3. System is to be designed to provide for installation, setup, and startup from outside of unit enclosure without need to open the enclosure door.
4. Factory calibrated and ready for operation after installation.
5. Internally wired to accommodate a single-point field power connection.

E. Performance:

1. Range: Full scale, zero to **[25]<Insert number>** percent oxygen.
2. Zero Drift: Within **[1]<Insert number>** percent per year.
3. Span Drift: Within **[10]<Insert number>** percent per year.
4. Repeatability: Within **[1]<Insert number>** percent of full scale.
5. Linearity: Within **[2]<Insert number>** percent of full scale.
6. Step Change Response Time: Within **[12]<Insert number>** seconds.

F. Enclosure:

1. NEMA 250, **[Type 4X]<Insert type>**.
2. Access to inside of enclosure, as well as to controller, display, and wiring connections, through full-length door on front of enclosure **[that requires key access]**.
3. Door with **[shatterproof]** window for viewing of visual display and indicator lights.
4. Equip enclosure with mounting brackets to attach unit to a flat surface.

G. Controller:

1. Password-protected access through full-function keypad.
2. Set:
 - a. Real-time clock.
 - b. Alarm levels.
 - c. Change span-gas values.
 - d. Display date of last calibration.
 - e. Display minimum, maximum, and average gas values.
 - f. Change address, future calibration time, and date.
3. Automatic return-to-normal-operation feature after calibration.
4. Date stamps last successful calibration.
5. Time and date stamps events.
6. Selectable lockout of output signals during calibration.
7. Logs minimum, maximum, and average gas concentrations over selected time intervals.

H. Visual Display:

1. Four-digit LED or backlight LCD display visible from front face of enclosure.
2. Display direct reading of gas concentration.
3. Displays system status indicators.
4. Visual Alarm Indication:
 - a. Three Separate Alarm Levels: Caution, Warning, and Alarm.
 - b. Separate Strobes for Warning and Alarm Conditions: Externally mount the two strobes on top of enclosure.
5. Indicate sensor nearing end of its useful life based on the sensor output, not on the time the sensor was in service.
6. Display average, minimum, and maximum gas concentrations of the sensor over selected time.
7. Malfunction Indication Alarm: Displays a separate unique character when an over-range or under-range condition exists, a sensor signal sensor is lost, or a set-point error or memory failure occurs.

I. Audible Alarm:

1. Activate audible horn when an alarm condition occurs.
2. Rate for [70][95] dB with selectable output tones.
3. Mount horn inside or on exterior of enclosure.
4. Activate horn through contact relay and set as normally open and common.

J. Operator Interface:

1. Audible Alarm Acknowledge Switch:
 - a. Push-button switch located on front door to silence audible alarm.
 - b. Switch is to reset latched alarms if normal gas conditions exist. Visual alarms are to remain on as long as alarms are exceeded.
2. Operating Modes and Parameters Selection: Selections listed are to be accomplished by use of switches, jumpers, or remote control not involving use of tools.
 - a. Display range value.
 - b. Latching or nonlatching mode for alarm set points.
 - c. Upscale or downscale acting alarms.

K. Output Signal:

1. Control Relays:
 - a. Provide one relay for each set-point level for each of three alarm levels.
 - b. Provide one relay for fault conditions.
 - c. Alarm and Fault Relays: Form "C," SPDT, rated for 5 A resistive at 250 V ac or 30 V dc.
 - d. Contacts are to be capable of being selected normally open or normally closed.
 - e. Alarm Relays: Normally de-energized.
 - f. Fault Relay: Normally energized.
2. Analog Output:
 - a. Two-wire, 4 to 20 mA, [isolated][or][nonisolated] current source.
 - b. Signal capable of operating into a [600]<Insert value> ohm load.

L. Sensor:

1. Electrochemical fuel-cell type that does not require periodic addition of reagents or equivalent technology that provides performance indicated, long-term stability, and reliability.
2. Replaceable without need for tools.
3. Minimum useful life of [two]<Insert number> years.
4. Mount sensor externally on side or bottom of enclosure, except where indicated on Drawings, mount sensor remote from enclosure.

a. Remote-Mounted Sensors:

- 1) Provide sensor in a separate NEMA 250, Type 4X enclosure, except when sensor is installed in a hazardous location, then enclosure is to be explosion-proof type suitable for application.
- 2) Provide sensor with cable for connecting to monitor.
- 3) Provide sensor with mounting hardware suitable for application.
- 4) For duct-mounted applications, provide sensor with kit for calibrating the sensor without removing sensor from duct.

M. Gas Sampling Pump:

1. Where required by application, provide a pump mounted inside the enclosure to provide a motive force to induce flow of gas sample across the sensor.
2. Signal to the sensor from the pump is to be in digital communication format to eliminate radio-frequency interference (RFI) and electromagnetic interference (EMI).
3. A flow sensor is to activate a relay when the gas sample falls below the acceptable flow rate to the sensor and is to indicate a loss of gas flow on the display.
4. Introduction of a calibration gas to the gas sensor is to be through an integral push-button valve. This push-button valve is to return to monitoring the sampled area when released.

N. Battery Backup:

1. Provide battery backup power supply to continue normal operation if normal power source is interrupted.
2. Transfer to battery backup is to be automatic and is to be indicated on the display.
3. Mount battery backup power supply inside enclosure.
4. Battery backup is to be continuously charged during normal operation.
5. Battery life is to be at least 0.5 hours with strobes flashing, alarm conditions asserted, and horn sounding.

O. Calibration:

1. Calibrate and adjust functions through nonintrusive handheld wireless remote control without opening enclosure door.
2. Enter calibration mode through handheld wireless remote control unit. The display of the monitor is to instruct operator on when to apply zero and span gas. System is to automatically adjust its internal settings to the proper calibration values without further intervention by operator. On completion of a successful calibration, system is to exit the calibration mode. Date stamp of last successful calibration is retained in the system internal memory, with capability to be indicated on display. If calibration is unsuccessful for any reason, the display is to show an unsuccessful calibration attempt and revert to its previous calibration settings.
3. Wireless method is to employ a digitally encoded infrared light beam.
4. Handheld wireless remote control is to let operator perform sensor zeroing and calibration.
5. Handheld wireless remote control is to let operator perform sensor zeroing and calibration, as well as activate all functions and features of the monitor.

6. Monitor infrared link is not to be affected by natural and fabricated low-level ambient light.

P. Automatic Calibration System:

1. Provide automatic calibration of all oxygen monitors installed. Number of automatic calibration systems is to be determined by supplier based on location and quantity of oxygen monitors.
2. Automatic calibration system is to, without manual intervention, periodically perform a complete calibration of the sensors.
3. System to exchange digital signals with sensors.
4. Automatic calibration is to be adjustable from as many as **[three]<Insert number>** times per day to only once every **[30]<Insert number>** days.
5. Suppress or disable sensor alarms until automatic calibration cycle is completed.
6. Initiate manual calibration of the sensor at any time with a handheld infrared remote control without the need to disable or turn off the automatic calibration system.
7. House the system in a separate NEMA 250, **[Type 4X]<Insert type>** enclosure from the oxygen monitoring system. Enclosure is to have provisions for wall mounting.
8. Digital displays are to indicate zero and when span gas is being applied to the sensor, status, and any fault condition.
9. Monitor calibration cylinders attached to the calibration system and light a fault indicator of insufficient gas pressure.

2.6 VOC SENSORS AND TRANSMITTERS

A. VOC Sensors and Transmitters, Duct Mounted:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Senva Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Senva Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Provide VOC sensors and transmitters from single manufacturer.
4. Description:
 - a. VOC sensor with metal-oxidizing element that varies resistance with contaminant gases.
 - b. Senses and responds to combined concentration of more than **[30]<Insert quantity>** contaminants commonly found in indoor environments.
5. Performance:
 - a. Measurement Range: Zero to **[100 percent][or][1000 ppb isobutene][1000 ppm ethanol]<Insert range>**.

- b. Ambient Relative Humidity: **[Zero to 90][5 to 95]<Insert humidity range>** percent noncondensing.
- c. Ambient Temperature: **[32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.

6. Output Signals:

- a. Analog Output Signal: **[4 to 20 mA][or][zero to 10 V dc]<Insert signal>** output signal, linearized to concentration.
- b. Digital Output Signal: **[SPDT]<Insert requirement>**.

7. Serial Communication: **[Modbus RTU]<Insert signal>**.

8. Enclosure: ABS plastic or Lexan.

B. VOC Sensors and Transmitters, Wall Mounted:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[ACI Automation; Automation Components Inc]**
- b. **[Building Automation Products Inc.; BAPI]**
- c. **[Senva Inc.]**
- d. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[ACI Automation; Automation Components Inc]**
- b. **[Building Automation Products Inc.; BAPI]**
- c. **[Senva Inc.]**
- d. **<Insert manufacturer's name>**

3. Source Limitations: Provide VOC sensors and transmitters, wall mounted, from single manufacturer.

4. Description:

- a. VOC sensor with metal-oxidizing element that varies resistance with contaminant gases.
- b. Senses and responds to combined concentration of more than **[30]<Insert quantity>** contaminants commonly found in indoor environments.

5. Performance:

- a. Measurement Range: Zero to **[100 percent][or][1000 ppb isobutene][1000 ppm ethanol]<Insert range>**.
- b. Ambient Relative Humidity: **[Zero to 90][5 to 95][or][10 to 95]<Insert humidity range>** percent noncondensing.
- c. Ambient Temperature: **[32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.

6. Output Signals:

- a. Analog Output Signal: **[4 to 20 mA][or][zero to 10 V dc]<Insert signal>** output signal, linearized to concentration.
- b. Digital Output Signal: **[SPDT]<Insert requirement>**.



7. Serial Communication: **[Modbus RTU]<Insert signal>**.
8. Enclosure: ABS plastic or Lexan.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments to verify actual locations of connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to **[seismic][or][external]** loads.
- D. Fastening Hardware:
 1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- F. Corrosive Environments:
 1. Use products that are suitable for environment to which they are subjected.
 2. If possible, avoid or limit use of materials in corrosive environments.
 - a. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure **[constructed of Type 316L stainless steel]**.
 - b. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.

3.3 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

- A. Mounting Location:
 - 1. Mount duct-mounted instruments at locations indicated on Drawings.
 - 2. Mount wall-mounted instruments in user-occupied space at locations indicated on Drawings.
 - 3. Mount instruments intended for wall-mounting using floor-supported freestanding pipe stands, or floor-supported structural support frames where direct-to-wall mounting is not possible. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- B. Mounting Height:
 - 1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height is to comply with codes and accessibility requirements.
 - 2. Mount instruments located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of **42 to 72 inches (1.1 to 1.6 m)** above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at **60 inches (1.5 m)**.
- C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.4 INSTALLATION OF CARBON MONOXIDE MONITORING SYSTEM, MULTIPOINT AIR SAMPLING

- A. Install sample points in monitored area to provide accurate measurement of gas concentration.
- B. Install exposed sampling points with a finished appearance consistent with other materials in space. Submit proposed products to be installed for review and approval.
- C. Individually install each sample point to the carbon monoxide monitoring system using tubing.
 - 1. Material: **[Copper][stainless steel][or][polyethylene installed in conduit]**.
 - 2. Size: As recommended by carbon monoxide system manufacturer for specific application; minimum size **[NPS 3/8 (DN 10)]<Insert pipe size>**.
 - 3. Use compression fittings at tubing connections.
 - 4. Comply with additional requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- D. If not indicated on Drawings, locate carbon monoxide monitoring system in a secured and serviceable location accessible to authorized personnel.
- E. Support carbon monoxide monitoring system enclosure from floor or wall. Support floor-mounted systems using a structural channel frame. Provide mounting brackets.

3.5 INSTALLATION OF OXYGEN MONITORING SYSTEM, SINGLE POINT CONTINUOUS

- A. Install monitor in space to provide an accurate measurement of gas concentration.
- B. Support oxygen monitoring system from wall.

3.6 ELECTRICAL CONNECTIONS

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.7 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."

3.8 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing is to have same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification on face[**and on face of ceiling directly below instruments concealed above ceilings**].

3.9 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.10 CHECKOUT PROCEDURES

- A. Check out installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation that impacts performance.
- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.11 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

- 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
- 2. Provide written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
- 3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
- 4. Equipment and procedures used for calibration are to comply with instrument manufacturer's written instructions.
- 5. Provide diagnostic and test equipment for calibration and adjustment.
- 6. Field instruments and equipment used to test and calibrate installed instruments are to have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent is to be checked by an instrument with an accuracy of 0.5 percent.
- 7. Calibrate each instrument in accordance with instrument instruction manual supplied by manufacturer.
- 8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
- 9. Comply with field-testing requirements and procedures in ASHRAE's Guideline 11, in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

- 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
- 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:

- 1. Check digital signals using a jumper wire.
- 2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Transmitters: Check and calibrate transmitters at zero, 50, and 100 percent of Project design values. **Field calibration is not required for instruments that have been factory calibrated and provided with certificates.]**

3.12 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes **[three][six][nine][12]**

months' full maintenance by **[skilled employees of gas system and equipment Installer][manufacturer's authorized service representative]**. Include **[monthly][quarterly][semiannual][annual]** preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

3.13 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 09 23 16



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 23 16	23 09 23 00	Direct Digital Control (DDC) System for HVAC
23 09 23 16	23 09 23 00a	Leak Detection Instruments
23 09 23 16	23 09 23 00b	Position Instruments
23 09 23 16	23 09 00 00	Speed Instruments
23 09 23 16	23 09 23 00c	Sequence of Operations for HVAC DDC



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 09 23 19 - MOISTURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Moisture switches.
2. Moisture sensors and transmitters.
3. Moisture and temperature sensors and transmitters.
4. Multifunction moisture and temperature sensors and transmitters.

B. Related Requirements:

1. Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, cable, and other requirements that relate to this Section.
2. Section 230923.27 "Temperature Instruments" for temperature sensors that combine moisture, gas, and other measurements into a single device.
3. Section 230993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Moisture switches.
2. Moisture sensors and transmitters.
3. Moisture and temperature sensors and transmitters.
4. Multifunction moisture and temperature sensors and transmitters.

B. Product Data Submittals: For each product.

1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Product description with complete technical data, performance curves, and product specification sheets.

C. Shop Drawings:

1. Details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Diagrams for power, signal, and control wiring.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.



1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For moisture instruments.

PART 2 - PRODUCTS

2.1 MOISTURE SWITCHES

- A. Humidistats for Duct Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - b. **[Johnson Controls, Inc.]**
 - c. **[Schneider Electric USA, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - b. **[Johnson Controls, Inc.]**
 - c. **[Schneider Electric USA, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain humidistats for duct applications from single manufacturer.
4. Description:
 - a. Two-position control.
 - b. Field-adjustable set point.
 - c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Performance:
 - a. Ambient Relative Humidity: **[Zero to 100][5 to 95]<Insert numbers>** percent.
 - b. Relative Humidity Control Range: **[15 to 95][30 to 90][35 to 100]<Insert numbers>** percent.
 - c. Relative Humidity Differential: **[4][5]<Insert number>** percent.
 - d. Ambient Temperature: **[40 to 125 deg F (4 to 52 deg C)]<Insert temperature range>**.
 - e. Voltage: **[24][120][or][240]<Insert value>** V ac.
 - f. Current: **[3.6][7.2]<Insert value>** FLA.
 - g. Switch Type: **[SPDT]<Insert type>** snap switch.
6. Construction:
 - a. Enclosure: Plastic or painted metal; NEMA 250, Type 1[, 4, or 4X].
 - b. Electrical Connections: Screw terminals.

B. Humidistats for Space Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - b. **[Johnson Controls, Inc.]**
 - c. **[Schneider Electric USA, Inc.]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - b. **[Johnson Controls, Inc.]**
 - c. **[Schneider Electric USA, Inc.]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain humidistats for space applications from single manufacturer.
4. Description:
 - a. Two-position control.
 - b. Field-adjustable set point.
 - c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Performance:
 - a. Ambient Relative Humidity: **[Zero to 100][5 to 95]<Insert numbers>** percent.
 - b. Relative Humidity Control Range: **[Zero to 70][10 to 90]<Insert numbers>** percent.
 - c. Relative Humidity Differential: **[4][5][6]<Insert number>** percent.
 - d. Ambient Temperature: **[40 to 100 deg F (4 to 38 deg C)][40 to 125 deg F (4 to 52 deg C)]<Insert temperature range>**.
 - e. Voltage: **[24][120][or][240]<Insert value>** V ac.
 - f. Switch Type: SPDT snap switch.
6. Construction:
 - a. Enclosure: Plastic or painted metal; NEMA 250, Type 1.
 - b. Electrical Connections: Cable or screw terminals.

2.2 MOISTURE SENSORS AND TRANSMITTERS

A. Moisture Sensors and Transmitters for Duct Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [ACI Automation; Automation Components Inc]
 - b. [Building Automation Products Inc.; BAPI]
 - c. [Greystone Energy Systems, Inc.]
 - d. [Johnson Controls, Inc.]
 - e. [MAMAC Systems, Inc.]
 - f. [Minco]
 - g. [Siemens Industry, Inc., Building Technologies Division]
 - h. [Telaire; a brand of Amphenol Thermometrics Inc.]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Building Automation Products Inc.; BAPI]
 - c. [Greystone Energy Systems, Inc.]
 - d. [Johnson Controls, Inc.]
 - e. [MAMAC Systems, Inc.]
 - f. [Minco]
 - g. [Siemens Industry, Inc., Building Technologies Division]
 - h. [Telaire; a brand of Amphenol Thermometrics Inc.]
 - i. <Insert manufacturer's name>
3. Source Limitations: Obtain moisture sensors and transmitters for duct applications from single manufacturer.
4. Description: Moisture measurement transmitter for use in duct and equipment applications.
5. Factory Calibration: Factory calibrate each transmitter to [NIST]traceable standards and include transmitter with calibration certificate.
6. Performance:
 - a. Relative Humidity Accuracy Including Non-Linearity, Hysteresis, and Repeatability:
 - 1) Operating Temperature Range between 32 to 122 Deg F (0 to 50 Deg C):
 - a) Within [1.5][2][3][5]<Insert number> percent from [zero to 90]<Insert numbers> percent relative humidity.
 - b) Within [2][2.5][3][4][5]<Insert number> percent from [90 to 95][90 to 100]<Insert numbers> percent relative humidity.
 - b. Relative Humidity Operating Stability: [Within 0.25 percent/year][Within 0.5 percent/year]<Insert requirement>.
 - c. Relative Humidity Range: [Zero to 100]<Insert numbers> percent.
 - d. Response Time: Within [10][20][50]<Insert number> seconds.
 - e. Operating Temperature Range: Select for application, but not less than [minus 40 to plus 140 deg F (minus 40 to plus 60 deg C)]<Insert temperature range>.
 - f. Maximum Air Velocity: As required by application, but not less than [0 to 4000 fpm (0 to 20.3 m/s)]<Insert velocity range>.
7. Display:
 - a. Application: Include transmitters with integral [backlit]LCD display[where indicated on Drawings]<Insert application requiring display>.
 - b. Display percent relative humidity and temperature in units indicated.

8. Duct Probe: **[Plastic material listed for use in airstream with filter][or][stainless steel with sintered filter]<Insert requirement>**.
9. Transmitter Enclosure:
 - a. Enclosure Mounting: **[Integral to][or][remote from]** duct probe.
 - b. Enclosure Material: **[Cast aluminum][Plastic][or][painted metal]**.
 - c. Enclosure Rating: NEMA 250, **[Type 1][or][Type 3R][Type 4][Type 4X]<Insert type>**.
10. Analog Output Signal: **[4 to 20 mA][or][0 to 5 V dc][0 to 10 V dc]<Insert signal requirements>**.
11. Communication Network Interface: **[BACnet MS/TP][or][Modbus RTU]<Insert network protocol>**.
12. Humidity Sensor: Manufacturer's choice to comply with requirements indicated.
13. Sensor Cables: Provide interconnecting cables, as required by the application, for transmitters located remotely from the humidity sensors.

B. Moisture Sensors and Transmitters for Space Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[MAMAC Systems, Inc.]**
 - f. **[Minco]**
 - g. **[Schneider Electric USA, Inc.]**
 - h. **[Siemens Industry, Inc., Building Technologies Division]**
 - i. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[MAMAC Systems, Inc.]**
 - f. **[Minco]**
 - g. **[Schneider Electric USA, Inc.]**
 - h. **[Siemens Industry, Inc., Building Technologies Division]**
 - i. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - j. **<Insert manufacturer's name>**
3. Source Limitations: Obtain moisture sensors and transmitters for space applications from single manufacturer.
4. Description: Moisture measurement transmitter for use in space applications.
5. Factory Calibration: Factory calibrate each transmitter to **[NIST]** traceable standards and include transmitter with calibration certificate.
6. Performance:
 - a. Relative Humidity Accuracy Including Non-Linearity, Hysteresis, and Repeatability:

- 1) Operating Temperature Range between 32 to 104 Deg F (0 to 40 Deg C):
 - a) Within [1.5][2][3][5]<Insert number> percent from [zero to 90]<Insert numbers> percent relative humidity.
 - b) Within [2][2.5][3][4][5]<Insert number> percent from [90 to 95][90 to 100]<Insert numbers> percent relative humidity.
 - b. Relative Humidity Operating Stability: [Within 0.5 percent/year]<Insert requirement>.
 - c. Relative Humidity Range: [Zero to 100]<Insert numbers> percent.
 - d. Response Time: Within [10][20]<Insert number> seconds.
 - e. Operating Temperature Range: Select for application, but not less than [32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>.
7. Display:
- a. Application: Include transmitters with integral [backlit]LCD display[where indicated on Drawings]<Insert application requiring display>.
8. Transmitter Enclosure:
- a. Enclosure Mounting: [Integral to][or][remote from] humidity sensor.
 - b. Enclosure Material: [Plastic][or][painted carbon steel or stainless steel].
 - c. Enclosure Rating: NEMA 250, [Type 1]<Insert type>.
9. Analog Output Signals: [4 to 20 mA][or][0 to 5 V dc][0 to 10 V dc]<Insert signal requirements>.
10. Communication Network Interface: [BACnet MS/TP][or][Modbus RTU]<Insert network protocol>.
11. Humidity Sensor: Manufacturer's choice to comply with requirements indicated.
12. Sensor Cables: Provide interconnecting cables, as required by the application, for transmitters located remotely from the humidity sensors.

2.3 MOISTURE AND TEMPERATURE SENSORS AND TRANSMITTERS

A. Moisture and Temperature Sensors and Transmitters for Duct Applications:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Building Automation Products Inc.; BAPI]
 - c. [Greystone Energy Systems, Inc.]
 - d. [Honeywell Building Solutions; Honeywell International, Inc.]
 - e. [Johnson Controls, Inc.]
 - f. [MAMAC Systems, Inc.]
 - g. [Minco]
 - h. [Rotronic Instrument Corporation; A PST Brand]
 - i. [Schneider Electric USA, Inc.]
 - j. [Siemens Industry, Inc., Building Technologies Division]
 - k. [Telaire; a brand of Amphenol Thermometrics Inc.]
 - l. [Vaisala]
 - m. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[MAMAC Systems, Inc.]**
 - g. **[Minco]**
 - h. **[Rotronic Instrument Corporation; A PST Brand]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - l. **[Vaisala]**
 - m. **<Insert manufacturer's name>**
3. Source Limitations: Obtain moisture and temperature sensors and transmitters for duct applications from single manufacturer.
4. Description: Moisture and temperature measurements combined in a single transmitter for use in duct and equipment applications.
5. Factory Calibration: Factory calibrate each transmitter to **[NIST]** traceable standards and include transmitter with calibration certificate.
6. Performance:
 - a. Relative Humidity Accuracy Including Non-Linearity, Hysteresis, and Repeatability:
 - 1) Operating Temperature Range between 32 to 104 Deg F (0 to 40 Deg C):
 - a) Within **[1.5][2][3][5]<Insert number>** percent from **[zero to 90]<Insert numbers>** percent relative humidity.
 - b) Within **[2][2.5][3][4][5]<Insert number>** percent from **[90 to 95][90 to 100]<Insert numbers>** percent relative humidity.
 - 2) Operating Temperature Range within the Remainder of the Temperature Range Indicated:
 - a) Within **[2][2.5][3][5]<Insert number>** percent from **[zero to 90]<Insert numbers>** percent relative humidity.
 - b) Within **[2][3][3.5][5]<Insert number>** percent from **[90 to 95][90 to 100]<Insert numbers>** percent relative humidity.
 - b. Relative Humidity Operating Stability: **[Within 0.25 percent/year][Within 0.5 percent/year]<Insert requirement>**.
 - c. Relative Humidity Range: **[Zero to 100]<Insert numbers>** percent.
 - d. Response Time: Within **[10][20]<Insert number>** seconds.
 - e. Temperature Accuracy:
 - 1) Within **[0.5 deg F (0.3 deg C)]<Insert temperature>** accuracy over the temperature range of **[50 to 100 deg F (10 to 38 deg C)]<Insert temperature range>**.
 - 2) Within **[1 deg F (0.6 deg C)]<Insert temperature>** when operating within the remainder of the temperature range.
 - f. Temperature Range: Select for application, but not less than **[minus 40 to plus 140 deg F (minus 40 to plus 60 deg C)]<Insert temperature range>**.



- g. Maximum Air Velocity: As required by application, but not less than [0 to 4000 fpm (0 to 20.3 m/s)]<Insert velocity range>.
- 7. Display:
 - a. Application: Include transmitters with integral [backlit]LCD display[where indicated on Drawings]<Insert application requiring display>.
 - b. Display percent relative humidity and temperature in units indicated.
- 8. Duct Probe: [Plastic material listed for use in airstream with filter][or][stainless steel with sintered filter]<Insert requirement>.
- 9. Transmitter Enclosure:
 - a. Enclosure Mounting: [Integral to][or][remote from] duct probe.
 - b. Enclosure Material: [Cast aluminum][Plastic][or][painted metal].
 - c. Enclosure Rating: NEMA 250, [Type 1][or][Type 3R][Type 4][Type 4X]<Insert type>.
- 10. Analog Output Signals: Two separate signals; [4 to 20 mA][or][0 to 5 V dc][0 to 10 V dc]<Insert signal requirements>. Include analog output signal for relative humidity and dry-bulb temperature.
- 11. Communication Network Interface: [BACnet MS/TP][or][Modbus RTU]<Insert network protocol>.
- 12. Humidity Sensor: Manufacturer's choice to comply with requirements indicated.
- 13. Temperature Sensor: [100-ohm platinum RTD][or][1000-ohm platinum RTD][10000-ohm Type II NTC thermistor][10000-ohm Type III NTC thermistor][20000-ohm NTC thermistor]<Insert requirement>.
- 14. Sensor Cables: Provide interconnecting cables, as required by the application, for transmitters located remotely from the humidity and temperature sensors.

B. Moisture and Temperature Sensors and Transmitters for Space Applications:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Building Automation Products Inc.; BAPI]
 - c. [Greystone Energy Systems, Inc.]
 - d. [Honeywell Building Solutions; Honeywell International, Inc.]
 - e. [Johnson Controls, Inc.]
 - f. [MAMAC Systems, Inc.]
 - g. [Minco]
 - h. [Rotronic Instrument Corporation; A PST Brand]
 - i. [Schneider Electric USA, Inc.]
 - j. [Siemens Industry, Inc., Building Technologies Division]
 - k. [Telaire; a brand of Amphenol Thermometrics Inc.]
 - l. [Vaisala]
 - m. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ACI Automation; Automation Components Inc]

- b. [Building Automation Products Inc.; BAPI]
 - c. [Greystone Energy Systems, Inc.]
 - d. [Honeywell Building Solutions; Honeywell International, Inc.]
 - e. [Johnson Controls, Inc.]
 - f. [MAMAC Systems, Inc.]
 - g. [Minco]
 - h. [Rotronic Instrument Corporation; A PST Brand]
 - i. [Schneider Electric USA, Inc.]
 - j. [Siemens Industry, Inc., Building Technologies Division]
 - k. [Telaire; a brand of Amphenol Thermometrics Inc.]
 - l. [Vaisala]
 - m. <Insert manufacturer's name>
3. Source Limitations: Obtain moisture and temperature sensors and transmitters for space applications from single manufacturer.
 4. Description: Moisture and temperature measurements combined in a single transmitter for use in space applications.
 5. Factory Calibration: Factory calibrate each transmitter to [NIST]traceable standards and include transmitter with calibration certificate.
 6. Performance:
 - a. Relative Humidity Accuracy Including Non-Linearity, Hysteresis, and Repeatability:
 - 1) Operating Temperature Range between 32 to 104 Deg F (0 to 40 Deg C):
 - a) Within [1.5][2][3][5]<Insert number> percent from [zero to 90]<Insert numbers> percent relative humidity.
 - b) Within [2][2.5][3][4][5]<Insert number> percent from [90 to 95][90 to 100]<Insert numbers> percent relative humidity.
 - 2) Operating Temperature Range within the Remainder of the Temperature Range Indicated:
 - a) Within [2][2.5][3][5]<Insert number> percent from [zero to 90]<Insert numbers> percent relative humidity.
 - b) Within [2][3][3.5][5]<Insert number> percent from [90 to 95][90 to 100]<Insert numbers> percent relative humidity.
 - b. Relative Humidity Operating Stability: [Within 0.5 percent/year]<Insert requirement>.
 - c. Relative Humidity Range: [Zero to 100]<Insert numbers> percent.
 - d. Response Time: Within [10][20]<Insert number> seconds.
 - e. Temperature Accuracy:
 - 1) Within [0.5 deg F (0.3 deg C)]<Insert temperature>accuracy over the temperature range of [50 to 100 deg F (10 to 38 deg C)]<Insert temperature range>.
 - 2) Within [1 deg F (0.6 deg C)]<Insert temperature> when operating within the remainder of the temperature range.
 - f. Temperature Range: Select for application, but not less than [32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>.
 7. Display:
 - a. Application: Include transmitters with integral [backlit]LCD display[where indicated on Drawings]<Insert application requiring display>.
 - b. Display percent relative humidity and temperature in units indicated.

8. Transmitter Enclosure:
 - a. Enclosure Mounting: **[Integral to][or][remote from]** humidity and temperature sensor.
 - b. Enclosure Material: **[Cast aluminum][or][plastic][painted metal]**.
 - c. Enclosure Rating: NEMA 250, **[Type 1][or][Type 4][Type 4X]<Insert type>**.
9. Analog Output Signals: Two separate signals; **[4 to 20 mA][or][0 to 5 V dc][0 to 10 V dc]<Insert signal requirements>**. Include analog output signal for relative humidity and dry-bulb temperature.
10. Communication Network Interface: **[BACnet MS/TP][or][Modbus RTU]<Insert network protocol>**.
11. Humidity Sensor: Manufacturer's choice to comply with requirements indicated.
12. Temperature Sensor: **[100-ohm platinum RTD][or][1000-ohm platinum RTD][10000-ohm Type II NTC thermistor][10000-ohm Type III NTC thermistor][20000-ohm NTC thermistor]<Insert requirement>**.
13. Sensor Cables: Provide interconnecting cables, as required by the application, for transmitters located remotely from the humidity and temperature sensors.

C. Moisture and Temperature Sensors and Transmitters for Outdoor Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[MAMAC Systems, Inc.]**
 - g. **[Minco]**
 - h. **[Rotronic Instrument Corporation; A PST Brand]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - l. **[Vaisala]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[MAMAC Systems, Inc.]**
 - g. **[Minco]**
 - h. **[Rotronic Instrument Corporation; A PST Brand]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - l. **[Vaisala]**

- m. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain moisture and temperature sensors and transmitters for outdoor applications from single manufacturer.
 4. Description: Moisture and temperature measurements combined in a single transmitter for use in outdoor applications.
 5. Factory Calibration: Factory calibrate each transmitter to **[NIST]**traceable standards and include transmitter with calibration certificate.
 6. Performance:
 - a. Relative Humidity Accuracy Including Non-Linearity, Hysteresis, and Repeatability:
 - 1) When operating within the temperature range indicated:
 - a) Within **[2][3][5]<Insert number>** percent from **[zero to 90]<Insert numbers>** percent relative humidity.
 - b) Within **[5]<Insert number>** percent from **[90 to 100]<Insert numbers>** percent relative humidity.
 - b. Relative Humidity Operating Stability: **[Within 1 percent/year]<Insert requirement>**.
 - c. Relative Humidity Range: **[Zero to 100]<Insert numbers>** percent.
 - d. Response Time: Within **[20][50]<Insert number>** seconds.
 - e. Temperature Accuracy:
 - 1) Within **[0.5 deg F (0.3 deg C)]<Insert temperature>**accuracy over the temperature range of **[50 to 100 deg F (10 to 38 deg C)]<Insert temperature range>**.
 - 2) Within **[1 deg F (0.6 deg C)]<Insert temperature>** when operating within the remainder of the temperature range.
 - f. Temperature Range: Select for application, but not less than **[minus 40 to plus 140 deg F (minus 40 to plus 60 deg C)]<Insert temperature range>**.
 7. Transmitter Enclosure:
 - a. Enclosure Mounting: **[Integral to][or][remote from]** humidity and temperature sensors.
 - b. Enclosure Material: **[Cast aluminum][Plastic][or][painted metal]**.
 - c. Enclosure Rating: NEMA 250, **[Type 3R][or][Type 4][Type 4X]<Insert type>**.
 8. Analog Output Signals: Two separate signals; **[4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>**. Include analog output signal for relative humidity and dry-bulb temperature.
 9. Humidity Sensor: Manufacturer's choice to comply with requirements indicated.
 10. Temperature Sensor: **[Platinum RTD][or][NTC thermistor]<Insert requirement>**.
 11. Sensor Cables: Provide interconnecting cables, as required by the application, for transmitters located remotely from the humidity and temperature sensors.
 12. Accessories: Include transmitter assembly with weather (solar radiation and precipitation) shield and mounting kit suitable for application.
- 2.4 MULTIFUNCTION MOISTURE AND TEMPERATURE SENSORS AND TRANSMITTERS
- A. Multifunction Moisture and Temperature Sensors and Transmitters:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [E+E Elektronik Corporation]
 - b. [Rotronic Instrument Corporation; A PST Brand]
 - c. [Vaisala]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [E+E Elektronik Corporation]
 - b. [Rotronic Instrument Corporation; A PST Brand]
 - c. [Vaisala]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain multifunction moisture and temperature sensors and transmitters from single manufacturer.
4. Description:
 - a. Factory package consisting of humidity and temperature sensors and transmitter, digital display, keypad or touchscreen display operator interface, installation hardware, interconnecting sensor cabling, installation instructions, and operating manual.
 - b. Temperature-compensated relative humidity measurement.
 - c. Interchangeable sensors.
 - d. Include signal conditioning and analog to digital conversion either at sensors, if offering smart sensors, or at transmitter to achieve performance indicated.
 - e. Provide a service cable for connecting to a notebook computer and Microsoft Windows-compatible software.
5. Factory Calibration: Factory calibrate each transmitter to [NIST]traceable standards and include transmitter with calibration certificate.
6. Performance:
 - a. Ambient Operating Temperature-Transmitter: [32 to 140 deg F (0 to 60 deg C)]<Insert temperature range>.
 - b. Relative Humidity Measurement Range: Zero to 100 percent.
 - c. Relative Humidity Accuracy Including Non-Linearity, Hysteresis, and Repeatability:
 - 1) For Temperature Range between 59 to 77 Deg F (15 to 25 Deg C):
 - a) Relative Humidity between Zero to 90 Percent: Within [0.8][1]<Insert number> percent.
 - b) Relative Humidity between 90 to 100 Percent: Within [1.7]<Insert number> percent.
 - 2) For Temperature Range between Minus 4 to Plus 104 Deg F (Minus 20 to Plus 40 Deg C): Within [1 percent plus 0.008 times relative humidity reading]<Insert accuracy>.
 - 3) For Temperature between Minus 40 to 356 Deg F (Minus 40 to Plus 180 Deg C): [Within 1.5 percent plus 0.015 times the relative humidity reading]<Insert accuracy>.
 - d. Relative Humidity Operating Stability: [Within 0.5 percent/year]<Insert requirement>.
 - e. Response Time: Within [20][40][60]<Insert value> seconds[in still air].
 - f. Temperature Accuracy:

- 1) Within [0.5 deg F (0.3 deg C)]<Insert temperature>accuracy over the temperature range of [50 to 100 deg F (10 to 38 deg C)]<Insert temperature range>.
- 2) Within [1 deg F (0.6 deg C)]<Insert temperature> when operating within the remainder of the temperature range.
- g. Temperature Range: Select for application, but not less than [minus 40 to plus 140 deg F (minus 40 to plus 60 deg C)]<Insert temperature range>.
7. Integral Data Logger with Real-Time Clock:
 - a. Parameters Logged: Up to [four]<Insert number> operator selectable parameters with measurement trend, minimum value and maximum value over time.
 - b. Measurement Interval: [10 seconds][Manufacturer's standard offering]<Insert requirement>.
 - c. Logged Measurement Storage: Up to [13 million measurements per parameter]<Insert requirement>.
 - d. Data History: Up to [one][four]<Insert number>-year period.
 - e. Include display with graphic of measurement trends, and minimum and maximum values over data history indicated.
8. Display:
 - a. Alphanumeric display of the following parameters on the face of the enclosure:
 - 1) Percent relative humidity.
 - 2) Absolute humidity.
 - 3) Mixing ratio.
 - 4) Dry-bulb temperature.
 - 5) Wet-bulb temperature.
 - 6) Dew point temperature.
 - 7) Enthalpy.
 - b. LCD display with backlight.
9. Transmitter Electronics Enclosure:
 - a. Enclosure Mounting: Integral to sensors for space-mounted applications unless otherwise indicated on Drawings. Install remote from temperature and humidity sensors for duct and equipment applications.
 - b. Material: Aluminum or aluminum alloy.
 - c. Rating: NEMA 250, Type 4 or 4X.
 - d. Electrical Connections: Labeled terminal strip for field wiring connections.
 - e. Conduit Connections: Minimum 1/2-inch (16-mm) trade size, threaded.
 - f. Mounting Kit: Suitable for specific field mounting application; wall, DIN rail, pipe stand.
10. Programming:
 - a. Parameters are field programmable through keypad on the face of the enclosure.
 - b. Store programmed parameters in nonvolatile memory (EEPROM).
11. Output Signals:
 - a. Analog Output Signals: [Two][Three] separate signals; [4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>. Include analog output signal for each of the following variables: [Relative humidity][Dry-bulb temperature]<Insert variable>.
 - b. Digital Output Signals: [One][Two][Three][Four] separate relay signals; [0.5]<Insert



value> A at **[240]**<Insert value> V ac. Include digital output signal for each of the following variables: <Insert variable>.

12. Communication Network Interface: **[Modbus RTU][or][Modbus TCP/IP]**<Insert network protocol>.
13. Humidity Sensor:
 - a. Capacitive thin-film polymer or manufacturer's choice to comply with requirements indicated.
 - b. Stainless steel sheath.
 - c. Sintered, stainless steel filter, protecting sensor.
 - d. Provide duct installation kit for duct and equipment applications.
14. Temperature Sensor:
 - a. Platinum RTD; **[100 ohms][or][1000 ohms]**<Insert resistance value>.
 - b. Provide duct installation kit for duct and equipment applications.
15. Sensor Cables: Provide interconnecting cables, as required by the application, for transmitters located remotely from the humidity and temperature sensors.
16. Power Supply:
 - a. Field Power: **[24][120][or][240]** V ac, 60 Hz, as required by the application.
 - b. Internal Power: Manufacturer's standard, as required by transmitter and sensors.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments to verify actual locations of connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 MOISTURE INSTRUMENT APPLICATIONS

- A. Humidistat for Duct Applications: <Insert application>.
- B. Humidistat for Space Applications: <Insert application>.
- C. Moisture Transmitter for Duct Applications: <Insert application>.
- D. Moisture Transmitter for Space Applications: <Insert application>.
- E. Moisture and Temperature Transmitter for Duct Applications: <Insert application>.
- F. Moisture and Temperature Transmitter for Space Applications: <Insert application>.

- G. Moisture and Temperature Transmitter for Outdoor Applications: **<Insert application>**.
- H. Multifunction Moisture and Temperature Transmitter: **<Insert application>**.

3.3 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to **[seismic][or][external]** loads.
- C. Fastening Hardware:
 - 1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, verify that unrestricted ladder placement is possible during occupied condition.
- E. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they are subjected.
 - 2. Where possible, avoid or limit use of materials in corrosive environments.
 - 3. When conduit is in a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 - 4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 INSTALLATION OF MOISTURE INSTRUMENTS

- A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, and conduit to final location.
- B. Mounting Height:
 - 1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height to comply with codes and accessibility requirements.
 - 2. Mount instruments located in mechanical equipment rooms and other similar space not subject to code, state, and Federal accessibility requirements within a range of **42 to 72 inches (1.1 to 1.6 m)** above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at **60 inches (1.5 m)**.
- C. Seal penetrations to ductwork, plenums, and equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.



3.5 ELECTRICAL CONNECTIONS

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."

3.7 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification[**on face of ceiling directly below instruments concealed above ceilings**].

3.8 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.9 CHECKOUT PROCEDURES

- A. Check installed products before continuity tests and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation that impacts performance.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
 - 4. Equipment and procedures used for calibration to comply with instrument manufacturer's written instructions.
 - 5. Provide diagnostic and test equipment for calibration and adjustment.
 - 6. Field instruments and equipment used to test and calibrate installed instruments to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent to be checked by an instrument with an accuracy of 0.5 percent.
 - 7. Calibrate each instrument in accordance with instrument instruction manual supplied by manufacturer.
 - 8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
 - 9. Comply with field-testing requirements and procedures indicated by ASHRAE's Guideline 11, in the absence of specific requirements, and to supplement requirements indicated.
- B. Analog Signals:
 - 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
- C. Digital Signals:
 - 1. Check digital signals using a jumper wire.
 - 2. Check digital signals using an ohmmeter to test for contact.
- D. Switches: Calibrate switches to make or break contact at set points indicated.
- E. Transmitters:
 - 1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values. **[Field calibration is not required for instruments that have been factory calibrated and provided with certificates.]**

3.11 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes **[three][six][nine][12]** months' full maintenance by **[skilled employees of systems and equipment Installer][manufacturer's authorized service representative]**. Include



[monthly][quarterly][semiannual][annual] preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper <Insert equipment> operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

3.12 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 09 23 19



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 23 19	23 09 23 00	Direct Digital Control (DDC) System for HVAC
23 09 23 19	23 09 23 00a	Leak Detection Instruments
23 09 23 19	23 09 23 00b	Position Instruments
23 09 23 19	23 09 00 00	Speed Instruments
23 09 23 19	23 09 23 00c	Sequence of Operations for HVAC DDC



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 09 23 21 - MOTION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Motion sensors - passive infrared.
2. Motion sensors - ultrasonic.
3. Motion sensors - dual technology.
4. Motion sensors - switchbox mounted.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, cable, and other requirements that relate to this Section.
2. Section 230923.27 "Temperature Instruments" for temperature sensors that combine motion detection into a single device.
3. Section 230993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.
4. Section 260923 "Lighting Control Devices" for occupancy and vacancy detectors used to control lighting[**and serve a dual purpose to also control HVAC systems**].

1.2 ACTION SUBMITTALS

A. Product Data:

1. Motion sensors - passive infrared.
2. Motion sensors - ultrasonic.
3. Motion sensors - dual technology.
4. Motion sensors - switchbox mounted.

B. Product Data Submittals: For each product.

1. Include operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Include product description with complete technical data, performance curves, and product specification sheets.

C. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Product installation location shown in relationship to visual range and obstructions.
 - 2. Wall- and ceiling-mounted instruments located in finished space showing relationship to other installed devices.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For motion instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 MOTION SENSORS - INDOOR

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - 2. **[Eaton]**
 - 3. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - 4. **[Leviton Manufacturing Co., Inc.]**
 - 5. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - 6. **[Lutron Electronics Co., Inc]**
 - 7. **[NSi Industries LLC]**
 - 8. **[Philips; Signify North America; Signify Holding]**
 - 9. **[RAB Lighting]**
 - 10. **[Sensor Switch, Inc]**
 - 11. **[Square D; Schneider Electric USA]**
 - 12. **[WattStopper; Legrand North America, LLC]**
 - 13. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - 2. **[Eaton]**
 - 3. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - 4. **[Leviton Manufacturing Co., Inc.]**
 - 5. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - 6. **[Lutron Electronics Co., Inc]**
 - 7. **[NSi Industries LLC]**
 - 8. **[Philips; Signify North America; Signify Holding]**
 - 9. **[RAB Lighting]**
 - 10. **[Sensor Switch, Inc]**

11. **[Square D; Schneider Electric USA]**
 12. **[WattStopper; Legrand North America, LLC]**
 13. **<Insert manufacturer's name>**
- C. Description: Wall- or ceiling-mounted, solid-state units with a separate relay unit.
- D. General Requirements for Sensors:
1. Sensor Operation: Unless otherwise indicated, operate HVAC according to occupied mode when covered area is occupied and operate HVAC according to unoccupied mode when unoccupied; with a time delay for turning off, adjustable over a minimum range of 1 to 15 minutes.
 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor powered from the relay unit.
 3. Relay Unit: Dry contacts rated for 20 A load at 120 and 277 V ac. Power supply to sensor is to be 24 V dc, 150 mA, Class 2 power source as defined by NFPA 70.
 4. DDC System Connection: **[Hardwired]<Insert requirement>**.
 5. Mounting:
 - a. Sensor: Suitable for mounting in any position in a standard device box or outlet box.
 - b. Relay: Externally mounted through a **1/2-inch (13-mm)** knock out in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 6. Indicator: Digital display, to show when motion is being detected during testing and normal operation of the sensor.
 7. Bypass Switch: Override the on function in case of sensor failure.
 8. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- E. Motion Sensors - Passive Infrared: **[Ceiling][or][wall]** mounting; detect occupancy by sensing a combination of heat and movement in coverage area.
1. Detector Sensitivity: Detect occurrences of **6-inch- (150-mm-)** minimum movement of any portion of a human body that presents a target of not less than **36 sq. in. (232 sq. cm)**.
 2. Detection Coverage (Room, Ceiling Mounted): Detect occupancy anywhere in a circular area of **1000 sq. ft. (93 sq. m)** when mounted on a **96-inch- (2440-mm-)** high ceiling.
 3. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of **[1000 sq. ft. (110 sq. m)][2000 sq. ft. (220 sq. m)][3000 sq. ft. (330 sq. m)]** when mounted **48 inches (1200 mm)** above finished floor.
 4. Detection Coverage (Corridor, Ceiling Mounted): Detect occupancy within **90 ft. (27.4 m)** when mounted on a **10-foot- (3-m-)** high ceiling.
- F. Motion Sensors - Ultrasonic: **[Ceiling][or][wall]** mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in coverage area.
1. Detector Sensitivity: Detect a person of average size and weight moving not less than **12 inches (305 mm)** in either a horizontal or a vertical manner at an approximate speed of **12 inches/s (305 mm/s)**.
 2. Detection Coverage (Small Room, Ceiling Mounted): Detect occupancy anywhere within a circular area of **600 sq. ft. (56 sq. m)** when mounted on a **96-inch- (2440-mm-)** high ceiling.
 3. Detection Coverage (Standard Room, Ceiling Mounted): Detect occupancy anywhere within a circular area of **1000 sq. ft. (93 sq. m)** when mounted on a **96-inch- (2440-mm-)** high ceiling.
 4. Detection Coverage (Large Room, Ceiling Mounted): Detect occupancy anywhere within a circular area of **2000 sq. ft. (186 sq. m)** when mounted on a **96-inch- (2440-mm-)** high ceiling.
 5. Detection Coverage (Corridor, Ceiling Mounted): Detect occupancy anywhere within **90 ft. (27.4 m)** when mounted on a **10-foot- (3-m-)** high ceiling in a corridor not wider than **14 ft.**

(4.3 m).

6. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of [1000 sq. ft. (110 sq. m)][2000 sq. ft. (220 sq. m)][3000 sq. ft. (330 sq. m)] when mounted 84 inches (2100 mm) above finished floor.

- G. Motion Sensors - Dual Technology: **[Ceiling][or][wall]** mounting; detect occupancy by using a combination of passive-infrared and ultrasonic detection methods in coverage area. A particular technology or combination of technologies that controls on-off functions is to be field selectable by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of **6-inch- (150-mm-)** minimum movement of any portion of a human body that presents a target of not less than **36 sq. in. (232 sq. cm)**, and detect a person of average size and weight moving not less than **12 inches (305 mm)** in either a horizontal or a vertical manner at an approximate speed of **12 inches/s (305 mm/s)**.
 3. Detection Coverage (Standard Room, Ceiling Mounted): Detect occupancy anywhere within a circular area of **1000 sq. ft. (93 sq. m)** when mounted on a **96-inch- (2440-mm-)** high ceiling. Apply occupancy detectors where indicated.
 4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of [1000 sq. ft. (110 sq. m)][2000 sq. ft. (220 sq. m)][3000 sq. ft. (330 sq. m)] when mounted 48 inches (1200 mm) above finished floor.
- H. Color: **[White]<Insert color>**.

2.2 MOTION SENSORS - SWITCHBOX MOUNTED

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 2. **[Eaton]**
 3. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 4. **[Leviton Manufacturing Co., Inc.]**
 5. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 6. **[Lutron Electronics Co., Inc]**
 7. **[NSi Industries LLC]**
 8. **[Philips; Signify North America; Signify Holding]**
 9. **[RAB Lighting]**
 10. **[Sensor Switch, Inc]**
 11. **[Square D; Schneider Electric USA]**
 12. **[WattStopper; Legrand North America, LLC]**
 13. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 2. **[Eaton]**
 3. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 4. **[Leviton Manufacturing Co., Inc.]**
 5. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 6. **[Lutron Electronics Co., Inc]**
 7. **[NSi Industries LLC]**

8. **[Philips; Signify North America; Signify Holding]**
 9. **[RAB Lighting]**
 10. **[Sensor Switch, Inc]**
 11. **[Square D; Schneider Electric USA]**
 12. **[WattStopper; Legrand North America, LLC]**
 13. **<Insert manufacturer's name>**
- C. Description: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox.
- D. General Requirements for Wall-Switch Motion Sensors:
1. Sensor Operation: Unless otherwise indicated, operate HVAC according to occupied mode when covered area is occupied and operate HVAC according to unoccupied mode when unoccupied; with a time delay for turning off, adjustable over a minimum range of 1 to 15 minutes.
 2. Operating Ambient Conditions: Dry interior conditions, **32 to 120 deg F (0 to 49 deg C)**.
 3. Switch Rating: Not less than 800 VA and 800 W.
 4. DDC System Connection: **[Hardwired]<Insert requirement>**.
 5. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- E. Wall-Switch Motion Sensor Tag WS1:
1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of **[900 sq. ft. (84 sq. m)][2100 sq. ft (196 sq. m)]**.
 2. Sensing Technology: **[Passive infrared][Dual technology - passive infrared and ultrasonic]**.
 3. Switch Type: **[SP.][SP, dual circuit.][SP, manual "on," automatic "off."][SP, field-selectable, automatic "on," or manual "on," automatic "off."]**
 4. Voltage: **[Match the circuit voltage][120 V][277 V][Dual voltage, 120 and 277 V]**.
 5. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
 6. Concealed "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
 7. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
 8. Color: **[White][Match color of room light switch]<Insert color>**.
 9. Faceplate: Color matched to switch.
- F. Wall-Switch Motion Sensor Tag WS2:
1. Standard Range: 210-degree field of view, with a minimum coverage area of **900 sq. ft. (84 sq. m)**.
 2. Sensing Technology: Passive infrared.
 3. Switch Type: **[SP.][SP, dual circuit.][SP, manual "on," automatic "off."][SP, field-selectable, automatic "on," or manual "on," automatic "off."]**
 4. Voltage: **[Match the circuit voltage][120 V][277 V][Dual voltage, 120 and 277 V]**.
 5. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
 6. Concealed "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
 7. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
 8. Color: **[White][Match color of room light switch]<Insert color>**.
 9. Faceplate: Color matched to switch.



PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF MOTION SENSORS

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- B. Coordinate layout and installation of wall-mounted devices with other wall-mounted devices. Align centerline with adjacent devices. Align centerline with devices above.
- C. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.3 ELECTRICAL CONNECTIONS

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.4 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.6 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to evaluate lighting control devices and perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections: Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Motion instruments will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.8 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for direct-digital control systems specified in Section 230923 "Direct-Digital Control (DDC) System for HVAC."
- B. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain motion instruments.



- C. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- D. Record Owner training and submit digital files with closeout documents for Owner's future use.

3.9 ADJUSTING

- A. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.
 - 1. Verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

END OF SECTION 23 09 23 21



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 23 21	23 09 23 00	Direct Digital Control (DDC) System for HVAC
23 09 23 21	23 09 23 00a	Leak Detection Instruments
23 09 23 21	23 09 23 00b	Position Instruments
23 09 23 21	23 09 00 00	Speed Instruments
23 09 23 21	23 09 23 00c	Sequence of Operations for HVAC DDC



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 09 23 23 - PRESSURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Air-pressure differential indicating transmitter, switch, and controller.
5. Liquid-pressure switches.
6. Liquid-pressure transmitters.
7. Room pressure monitors.

B. Related Requirements:

1. Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993.11 "Sequence of Operations for HVAC DDC" for sequences of operation requirements that relate to this Section.

1.2 DEFINITIONS

- A. HART:** Highway addressable remote transducer protocol.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over the instrument operating range, control signal over the instrument operating range, default control signal to be used by controller with loss of power to instrument, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and **[mounting]** details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.



1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Product installation location shown in relationship to room, duct, pipe, and equipment.
 - 2. Wall-mounted instruments located in finished space, showing relationship to light switches, fire alarm devices, and other installed devices.
 - 3. Size and location of wall access panels for instruments installed behind walls.
 - 4. Size and location of ceiling access panels for instruments installed in accessible ceilings.
- B. Product Certificates: For each product requiring a certificate.
- C. Product Test Reports: For each product requiring test performed by **[manufacturer and witnessed by a qualified testing agency][a qualified testing agency]**.
- D. Source quality-control reports.
- E. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Environmental Conditions:
 - 1. Instruments must operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - a. If instrument alone cannot comply with requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure is to be internally insulated, electrically heated **[and cooled]**, filtered, and ventilated as required by instrument and application.
 - 2. Protect instruments and accessories with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated are to be housed in protective secondary enclosures. Base NEMA 250 enclosure requirements on instrument-installed locations as follows:
 - a. Outdoors, Protected: **[Type 2][Type 3][Type 12]<Insert type>**.
 - b. Outdoors, Unprotected: **[Type 4][Type 4X]<Insert type>**.
 - c. Indoors, Heated with Filtered Ventilation: **[Type 1][Type 2]<Insert type>**.
 - d. Indoors, Heated with Nonfiltered Ventilation: **[Type 2][Type 12]<Insert type>**.
 - e. Indoors, Heated and Air-Conditioned: **[Type 1]<Insert type>**.

- f. Mechanical Equipment Rooms:
 - 1) Chiller and Boiler Rooms: **[Type 12][Type 4][Type 4X]<Insert type>**.
 - 2) Air-Moving Equipment Rooms: **[Type 1][Type 2][Type 12]<Insert type>**.
- g. Localized Areas Exposed to Washdown: **[Type 4][Type 4X]<Insert type>**.
- h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: **[Type 2][Type 3][Type 12]<Insert type>**.
- i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: **[Type 4][Type 4X]<Insert type>**.
- j. Hazardous Locations: Explosion-proof rating for condition.
- k. **<Insert location and enclosure requirements>**.

2.2 AIR-PRESSURE SENSORS

- A. Air-Pressure Sensor, Static Pressure Duct Insertion Type - 90-Degree Probe Design with Compression Fitting Tubing Connection:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
 - 3. Process Connection: Compression fitting.
 - 4. Construction Materials: **[Brass][or][stainless steel]**.
 - 5. Insertion Length: **[4 inches (100 mm)][6 inches (150 mm)][8 inches (200 mm)][or][12 inches (300 mm)]**.
 - 6. Mounting: Sensor with threaded end support, sealing washers and nuts.
 - 7. Pressure Measurement: Tip of sensor facing direction of airstream with four radial holes of **0.04-inch (1-mm)** diameter.
 - 8. Pressure Signal Dampener: Provide sensor assembly with dampener designed to minimize erratic and rapid fluctuations in pressure signal.
 - 9. Duct Types: Suitable for flat oval, rectangular, and round duct configurations.
- B. Air-Pressure Sensor, Static Pressure Duct Insertion Type - 90-Degree Probe Design with Barb Tubing Connection:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
3. Process Connection: Barb connection for use with polyethylene tubing.
4. Construction Materials: **[Brass][or][stainless steel]**.
5. Insertion Length: **[4 inches (100 mm)][or][6 inches (150 mm)]**.
6. Mounting: Sensor with threaded end support, sealing washers and nuts.
7. Pressure Measurement: Tip of sensor facing direction of airstream with four radial holes of **0.04-inch (1-mm)** diameter.
8. Pressure Signal Dampener: Provide sensor assembly with dampener designed to minimize erratic and rapid fluctuations in pressure signal.
9. Duct Types: Suitable for flat oval, rectangular, and round duct configurations.

C. Air-Pressure Sensor, Static Pressure Duct Insertion Type - Straight Probe with Barb Tubing Connection:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Cleveland Controls Inc.]**
 - c. **[Dwyer Instruments, Inc]**
 - d. **[Greystone Energy Systems, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Cleveland Controls Inc.]**
 - c. **[Dwyer Instruments, Inc]**
 - d. **[Greystone Energy Systems, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Process Connection: Barb connection for use with polyethylene tubing.
4. Construction Materials: **[Aluminum][or][Stainless steel]**.
5. Insertion Length: **[None required][4 inches (100 mm)][6 inches (150 mm)][8 inches (200 mm)][or][12 inches (300 mm)]<Insert length requirement>**.
6. Mounting: Sensor with duct-mounting flange and sealing gasket.
7. Pressure Measurement: Single orifice located at open end of straight probe.
8. Pressure Signal Dampener: Provide sensor assembly with dampener to minimize erratic and rapid fluctuations in pressure signal.
9. Duct Types: Suitable for flat oval, rectangular, and round duct configurations.

D. Air-Pressure Sensor, Static Pressure Duct Insertion Type - Dual-Orifice Design:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. **[MAMAC Systems, Inc.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[MAMAC Systems, Inc.]**
 - b. **<Insert manufacturer's name>**
 3. Process Connection: Barb fitting for connection to polyethylene tubing.
 4. Construction Material: 6061-T6 aluminum alloy.
 5. Insertion Length: **[4 inches (100 mm)][or][8 inches (200 mm)]**.
 6. Mounting: Sensor probe attached to a mounting flange with neoprene gasket and two holes for fasteners.
 7. Pressure Measurement: Sensor probe with two opposing orifices designed to reduce error-associated air velocity.
 8. Pressure Rating: **10 psig (69 kPa)**.
 9. Pressure Signal Dampener: Provide sensor assembly with dampener designed to minimize erratic and rapid fluctuations in pressure signal.
 10. Duct Types: Suitable for flat oval, rectangular, and round duct configurations.
- E. Air-Pressure Sensor, Static Pressure Duct Traverse Type:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[Paragon Controls Incorporated]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[Paragon Controls Incorporated]**
 - c. **<Insert manufacturer's name>**
 3. Description: Sensor to traverse the duct cross section and have at least one pickup point every **[6 inches (150 mm)]<Insert distance>** along length of sensor.
 4. Design: Dual offset static sensor designed to provide accurate sensing of duct static pressure in the presence of turbulent and rotational airflows with a maximum 30-degree yaw and pitch.
 5. Performance:
 - a. Accuracy: Within **[1][2]<Insert value>** percent of actual operating static pressure.
 - b. Air Resistance (Pressure Drop): Less than **[0.1]<Insert value>** times the velocity pressure at probe-operating velocity.
 - c. Temperature: Up to **[200 deg F (93 deg C)][400 deg F (204 deg C)]<Insert temperature>**.
 - d. Velocity: **[0 to 10000 fpm (0 to 51 m/s)]<Insert velocity>**.
 6. Process Connection: Mounting plate with threaded compression fitting for connection to tubing or



threaded NPT connection.

7. Construction Material: **[Type T6063-T5 extruded and anodized aluminum][or][Type 316 stainless steel]**.
8. Mounting: Sensor supported with noncorrosive threaded rod, sealing washer, and nut at one end and a mounting plate with gasket at opposite end.
9. Pressure Signal Dampener: Provide sensor assembly with dampener to minimize erratic and rapid fluctuations in pressure signal.
10. Duct Type: Suitable for flat oval, rectangular, and round duct configurations.

F. Air-Pressure Sensor, Static Pressure Outdoor Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Provides average outdoor static pressure signal.
4. Sensor with no moving parts.
5. Kit includes sensor and mounting hardware.

G. Air-Pressure Sensor, Static Pressure Outdoor Type - NEMA 250, Type 4X Enclosure:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **<Insert manufacturer's name>**

3. Provides average outdoor pressure signal.
 4. Sensor with no moving parts.
 5. NEMA 250, Type 4X enclosure.
 6. Process Connection: Barb fitting.
 7. Conduit fitting around pressure fitting for sensor support and protection to pressure connection.
- H. Air-Pressure Sensor, Static Pressure Outdoor Type - Unaffected/Unimpaired by Rain and Snow:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[Paragon Controls Incorporated]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[Paragon Controls Incorporated]**
 - c. **<Insert manufacturer's name>**
 3. Description: Shielded static pressure sensor suitable for exterior applications, used as outdoor pressure reference for space static pressure control. Sensor has multiple sensing ports, pressure impulse suppression chamber, and air-velocity shielding but no moving parts.
 4. Design: Two parallel pressure-sensing plates with a uniform space between the plates.
 5. Performance:
 - a. Accuracy, Outdoor Atmospheric Pressure:
 - 1) Within 1 percent of actual value while subjected to varying horizontal radial wind velocities up to **40 mph (17 m/s)**.
 - 2) Within 2 percent of actual value while subjected to varying radial wind velocities up to **[40 mph (17 m/s)][80 mph (34 m/s)]** with approach angles up to 30 degrees to horizontal.
 - 3) Within 3 percent of actual value while subjected to varying radial wind velocities up to **40 mph (17 m/s)** with approach angles up to 60 degrees to horizontal.
 - b. Operation not affected and impaired by rain and snow.
 6. Connection: Threaded female NPT, **[1/2 inch (15 mm)][or][2 inches (50 mm)]**.
 7. Construction Materials: **[Type 6061 aluminum][Type 304 stainless steel][or][Type 316 stainless steel]**.
- I. Air-Pressure Sensor, Static Pressure Space Type for Wall Mounting - Stainless Steel Wall Plate:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**

- c. **[Greystone Energy Systems, Inc.]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **<Insert manufacturer's name>**
 - 3. Sintered stainless steel filter mounted in stainless steel wall plate senses static pressure.
 - 4. Wall plate provided with gasket and screws, and sized to fit standard single-gang electrical box.
 - 5. Back of sensor plate fitted with barb fitting for tubing connection.
- J. Air-Pressure Sensor, Static Pressure Space Type for Wall Mounting - ABS Plastic Wall Plate:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[MAMAC Systems, Inc.]**
 - e. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Building Automation Products Inc.; BAPI]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[MAMAC Systems, Inc.]**
 - e. **<Insert manufacturer's name>**
 - 3. White ABS plastic wall plate with integral sensing port to sense static pressure.
 - 4. Wall plate provided with matching colored screws and sized to fit standard single-gang electrical box.
 - 5. Not affected by germicidal or sanitizing cleaning and washdown.
 - 6. Back of sensor plate fitted with union or barb fitting for tubing connection.
- K. Air-Pressure Sensor, Static Pressure Space Type - with Published Performance for Wall Mounting:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[Paragon Controls Incorporated]**
 - c. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[Paragon Controls Incorporated]**
 - c. **<Insert manufacturer's name>**
 3. Description: Flush-mounted wall plate with multiple sensing ports and pressure impulse suppression chamber.
 4. Performance: Within 1 percent of actual room static pressure in vicinity of sensor[**while being subjected to an air velocity of 1000 fpm (5.1 m/s) from a 360-degree radial source**].
 5. Connection: Barb or NPT fitting for connection to field-installed tubing.
 6. Construction:
 - a. Material: **[Aluminum][or][Stainless steel]**.
 - b. Exposed surfaces with brush finish.
 - c. Provide wall plate with matching screws.
 - d. Fits a standard single-gang electrical box.
- L. Air-Pressure Sensor, Static Pressure Space Type - with Published Performance for Recessed Ceiling Mounting:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[Paragon Controls Incorporated]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **[Paragon Controls Incorporated]**
 - c. **<Insert manufacturer's name>**
 3. Description: Sensor intended for flush mount sensor face on face of ceiling with sensor pressure chamber recessed in ceiling plenum.
 4. Performance: Within 1 percent of actual room static pressure in vicinity of sensor[**while being subjected to an air velocity of 1000 fpm (5.1 m/s) from a 360-degree radial source**].
 5. Connection: Threaded NPT fitting or compression fitting for concealed connection to field installed tubing.
 6. Construction:
 - a. Material: **[Aluminum][or][Stainless steel]** round plate with perforated center arranged to sense space static pressure.
 - b. Exposed surfaces with brush finish.
 - c. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, and airflow shielding.
- M. Air-Pressure Sensor, Static Pressure Space Type - with Published Performance for Exposed Surface or Suspended Ceiling Mounting:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **<Insert manufacturer's name>**
3. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of **1000 fpm (5.1 m/s)** from a 360-degree radial source.
4. Construction:
 - a. Material: **[Aluminum][Stainless steel]** with perforations arranged to sense space static pressure.
 - b. Sensor fitted with multiple sensing ports, pressure impulse suppression chamber, and airflow shielding.
5. Exposed Surface-Mounted Sensor:
 - a. Solid mounting plate intended for mounting to face of ceiling with sensor pressure chamber exposed to view.
 - b. Connection: **0.125-inch (3-mm)** NPT fitting or compression fitting for exposed tubing connection.
6. Suspended Ceiling-Mounted Sensor:
 - a. Intended for pendent mount with pressure chamber exposed to view.
 - b. Connection: **1/2-inch (15-mm)** NPT fitting for exposed pipe or tubing connection.

2.3 AIR-PRESSURE SWITCHES

A. Air-Pressure Switch, Differential Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Cleveland Controls Inc.]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Johnson Controls, Inc.]**
 - d. **[Penn Controls]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Cleveland Controls Inc.]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Johnson Controls, Inc.]**
 - d. **[Penn Controls]**
 - e. **<Insert manufacturer's name>**
 3. Description: Diaphragm operated to actuate an SPDT snap switch.
 - a. Fan Safety Shutdown Applications: Switch with manual reset and SPST snap switch.
 4. Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 5. Performance:
 - a. Accuracy/Repeatability: Within **[3]<Insert value>** percent of set point.
 - b. Electrical Rating: **[15 A at 120 to 480 V ac][15 A at 120 to 277 V ac]<Insert electrical rating>**.
 - c. Pressure Limits:
 - 1) Continuous: **[45 inches wg (11 kPa)]<Insert pressure>**.
 - 2) Surge: **[10 psig (69 kPa)]<Insert pressure>**.
 - d. Pressure Range: Approximately **[2]<Insert value>** times set point.
 - e. Temperature Limits: **[Minus 30 to plus 180 deg F (Minus 34 to plus 82 deg C)]<Insert temperature limits>**.
 6. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
 7. Process Connections: Threaded NPT or compression fittings.
 8. Conduit Connections: Knock out or threaded connection(s) for trade-size conduit.
 9. Wiring Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
 10. Enclosure Material: Corrosion-resistant metal.
 11. Enclosure Rating:
 - a. Dry Indoor Installations: NEMA 250, Type 1.
 - b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
 - c. Hazardous Environments: Explosion proof.
- B. Air-Pressure Switch, Differential Type - with Set-Point Indicator:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
 3. Description: Diaphragm operated to actuate an SPDT snap switch.

4. Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Performance:
 - a. Accuracy/Repeatability: Within 1 percent.
 - b. Electrical Rating: 15 A at 120 to 480 V ac.
 - c. Pressure Limits:
 - 1) Continuous: **10 psig (69 kPa)**.
 - 2) Surge: **25 psig (172 kPa)**.
 - d. Pressure Range: Approximately [2]<Insert value> times set point.
 - e. Temperature Limits: **Minus 30 to plus 110 deg F (Minus 34 to plus 43 deg C)**.
6. User Interface: Screw-type set-point adjustment with visible enclosed set-point indicator and scale.
7. Process Connections: Threaded NPT, **1/8 inch (3 mm)**.
8. Conduit Connection: Knock out or threaded connection.
9. Wiring Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
10. Enclosure Material: Corrosion-resistant metal.
11. Enclosure Rating:
 - a. Dry Indoor Installations: NEMA 250, Type 1.
 - b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.

C. Air-Pressure Switch, Differential Type - with Dual-Scale Adjustable Set Point:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **<Insert manufacturer's name>**
3. Description: Diaphragm operated to actuate an SPDT snap switch.
4. Performance:
 - a. Electrical Rating: **[1.5 A at 250 V ac]<Insert electrical rating>**.
 - b. Pressure Limits: **[40 inches wg (10 kPa)]<Insert pressure>**.
 - c. Pressure Range: Approximately [2]<Insert value> times set point.

- d. Temperature Limits: [Minus 4 to plus 185 deg F (Minus 20 to plus 85 deg C)]<Insert pressure>.
 - 5. User Interface: Dual-scale set-point adjustment knob located inside removable enclosure cover.
 - 6. Process Connections: Slip-on tubing connections.
 - 7. Conduit Connection(s): Knock out or threaded connection(s).
 - 8. Wiring Connections: Push-on screw terminals.
 - 9. Enclosure Material: Plastic.
 - 10. Enclosure Rating:
 - a. Dry Indoor Installations: NEMA 250, Type 13.
- D. Air-Pressure Switch, Differential Type - with Indicator:
- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Dwyer Instruments, Inc]
 - b. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Dwyer Instruments, Inc]
 - b. <Insert manufacturer's name>
 - 3. Description: Combination gauge with integral low- and high-limit switches.
 - 4. Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 5. Performance:
 - a. Accuracy:
 - 1) 4 percent for ranges through **0.5 in. wg (125 Pa)**.
 - 2) 2 percent for ranges **1 in. wg (250 Pa)** and greater.
 - b. Repeatability: Within 1 percent of full scale.
 - c. Switch Deadband: One pointer width and within 1 percent of full scale for each switch set point.
 - d. Electrical Rating: 10 A at 120 to 240 V ac.
 - e. Pressure Limits: **25 psig (172 kPa)**.
 - f. Pressure Range: Approximately [2]<Insert value> set point unless otherwise required for application.
 - g. Temperature Limits: **20 to 120 deg F (Minus 7 to plus 49 deg C)**.
 - 6. User Interface: Switch zero and set-point [tamperproof]adjustment screws or knobs on the display face.
 - 7. Display: Nominal **4-inch- (100-mm-)** diameter analog indication with white dial face, graduated black markings, pointer to indicate measured value, and a separate adjustable pointer for each switch set point.
 - 8. Process Connections: Threaded NPT, **1/8 inch (3 mm)**.
 - 9. Conduit Connection(s): **3/4-inch (20-mm)** threaded NPT connection(s).
 - 10. Wiring Connections: Screw terminals.

11. Enclosure Material: Plastic.
12. Enclosure Rating:
 - a. Dry Indoor Installations: NEMA 250, Type 1.
13. Power Supply: **[24][or][120]** V ac, 50/60 Hz.
14. Switches:
 - a. Each switch used as a safety limit to have a manual reset button local to switch.
 - b. Type: Each switch set point to have two Form C relays, DPDT.

2.4 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Transmitter, Differential Type - with Display:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ashcroft Inc]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Paragon Controls Incorporated]**
 - d. **[Setra Systems Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ashcroft Inc]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Paragon Controls Incorporated]**
 - d. **[Setra Systems Inc.]**
 - e. **<Insert manufacturer's name>**
3. Performance:
 - a. Range: Approximately **[2]<Insert value>** times set point.
 - b. Accuracy: Within **[0.25][0.4][0.5][1]<Insert value>** percent of the full-scale range.
 - c. Hysteresis: Within **[0.10]<Insert value>** percent of full scale.
 - d. Repeatability: Within **[0.05]<Insert value>** percent of full scale.
 - e. Stability: Within **[0.1]<Insert value>** percent of full scale range.
 - f. Overpressure: **[10 psig (69 kPa)][25 psig (172 kPa)]<Insert pressure>**.
 - g. Temperature Limits: **[Zero to 150 deg F (Minus 18 to plus 66 deg C)]<Insert temperature>**.
 - h. Compensated Temperature Limits: **[40 to 150 deg F (4 to 66 deg C)]<Insert temperature>**.
 - i. Thermal Effects: **[0.033]<Insert value>** percent of full scale per degree F.
 - j. Transmitter is to be shock and vibration tolerant without impacting performance.
4. Output Signals:
 - a. Analog Current Signal:

- 1) Two-wire, 4 to 20 mA dc current source.
 - 2) Signal capable of operating into 800-ohm load.
 - b. Analog Voltage Signal:
 - 1) Three wire, zero to **[5][or][10]** V.
 - 2) Minimum Load Resistance: 1000 ohms.
 5. Display: Four-digit digital display with minimum **0.4-inch- (10-mm-)** high numeric characters.
 6. Operator Interface: Zero and span adjustments located on face or behind cover.
 7. Construction:
 - a. Enclosure Material: Plastic enclosure with removable plastic cover.
 - b. Enclosure Rating: NEMA 250, **[Type 2][Type 4][or][Type 4X]<Insert type>**
 - c. Process Connections: Threaded, NPT swivel fittings for connection to copper tubing or barb fittings for connection to polyethylene tubing.
 - d. Wiring Connections: Screw terminal block; reverse wiring protected.
 - e. Mounting: Vertical plane mounting.
 - f. Provide mounting bracket suitable for installation.
 8. Factory Calibration: Calibrate to NIST-traceable standards and provide a certificate of calibration for each transmitter.
- B. Air-Pressure Transmitter, Differential Type:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ashcroft Inc]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[MAMAC Systems, Inc.]**
 - d. **[Paragon Controls Incorporated]**
 - e. **[Setra Systems Inc.]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ashcroft Inc]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[MAMAC Systems, Inc.]**
 - d. **[Paragon Controls Incorporated]**
 - e. **[Setra Systems Inc.]**
 - f. **<Insert manufacturer's name>**
 3. Performance:
 - a. Range: Approximately **[2]<Insert value>** times set point.
 - b. Accuracy: Within **[0.25][0.4][0.5][1]<Insert value>** percent of the span at reference temperature of **70 deg F (21 deg C)**.
 - c. Hysteresis: Within **[0.02]<Insert value>** percent of the span.
 - d. Repeatability: Within **[0.05]<Insert value>** percent of the calibrated span.
 - e. Stability: Within **[0.25]<Insert value>** percent of span per year.

- f. Overpressure: [10 psig (69 kPa)][25 psig (172 kPa)]<Insert pressure>.
- g. Temperature Limits: [Minus 20 to plus 160 deg F (Minus 29 to plus 71 deg C)]<Insert temperature>.
- h. Compensated Temperature Limits: [35 to 135 deg F (2 to 57 deg C)]<Insert temperature>.
- i. Thermal Effects: [0.015]<Insert value> percent of full scale per degree F.
- j. Warm-up Time: Within [5]<Insert value> seconds.
- k. Response Time: [5 ms][250 ms][One second].
- l. Transmitter is to be shock and vibration tolerant without impacting performance.

4. Output Signals:

a. Analog Current Signal:

- 1) Two-wire, 4 to 20 mA dc current source.
- 2) Signal capable of operating into 1000 ohm load.

b. Analog Voltage Signal:

- 1) Three wire, zero to [5][or][6][10] V.
- 2) Minimum Load Resistance: 1000 ohms.

5. Operator Interface:

- a. Zero and span adjustments within [5][10]<Insert value> percent of full span.
- b. Potentiometer adjustments located on face of transmitter or behind cover.

6. Construction:

- a. Enclosure Material: Stainless steel [or][plastic].
- b. Enclosure Rating: NEMA 250, [Type 2][Type 4][or][Type 4X].
- c. Process Connections: Threaded, NPT swivel fittings for connection to copper tubing or barb fittings for connection to polyethylene tubing.
- d. Wiring Connections: Screw terminal block. Reverse wiring protected.
- e. Mounting: Vertical plane mounting.
- f. Mounting Bracket: Appropriate for installation.

7. Factory Calibration: Calibrate to NIST-traceable standards and provide a certificate of calibration for each transmitter.

C. Air-Pressure Transmitter, Differential Type - for Hazardous Environments:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ashcroft Inc]
 - b. [Dwyer Instruments, Inc]
 - c. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Ashcroft Inc]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **<Insert manufacturer's name>**
3. Hazardous Environments:
 - a. FM Approved for hazardous environments.
 - b. Intrinsically safe for Classes I, II, and III, Divisions 1 and 2, and Groups A through H.
 - c. **<Insert requirements>**.
4. Performance:
 - a. Range: Approximately **[2]<Insert value>** times set point.
 - b. Accuracy: Within **[0.25][0.5]<Insert value>** percent of the span at reference temperature of **[70 deg F (21 deg C)]<Insert temperature>**.
 - c. Hysteresis: Within **[0.02]<Insert value>** percent of the span.
 - d. Repeatability: Within **[0.05]<Insert value>** percent of the calibrated span.
 - e. Stability: Within **[0.25]<Insert value>** percent of span per year.
 - f. Overpressure: **[20 psig (138 kPa)]<Insert pressure>**.
 - g. Temperature Limits: **[Minus 20 to plus 185 deg F (Minus 29 to plus 85 deg C)]<Insert temperature>**.
 - h. Compensated Temperature Limits: **[0 to 160 deg F (Minus 18 to plus 71 deg C)]<Insert temperature>**.
 - i. Thermal Effects: **[0.01]<Insert value>** percent of full scale per degree F.
 - j. Warm-up Time: Within **[5]<Insert value>** seconds.
 - k. Response Time: **[250]<Insert value>** ms.
 - l. Transmitter is to be shock and vibration tolerant without impacting performance.
5. Output Signals:
 - a. Analog Current Signal:
 - 1) Two-wire, 4 to 20 mA dc current source.
 - 2) Signal capable of operating into 1000-ohm load.
 - b. Analog Voltage Signal:
 - 1) Three wire, zero to **[5][or][6][10]** V.
 - 2) Minimum Load Resistance: 1000 ohms.
6. Operator Interface:
 - a. Zero and span adjustments within **[10]<Insert value>** percent of full span.
 - b. Potentiometer adjustments located on face of transmitter.
7. Construction:
 - a. Enclosure Material: Plastic.
 - b. Enclosure Rating: NEMA 250, Type 4X.
 - c. Process Connections: Threaded NPT connections for connection to tubing. Fittings are to be on bottom of instrument enclosure.
 - d. Conduit Connections: Two **1/2-inch (16-mm)** trade-size conduit connections isolated from electronics.
 - e. Wiring Connections: Screw terminal block; reverse wiring protected.
 - f. Mounting: Vertical plane mounting.
 - g. Mounting Bracket: Appropriate for installation.

8. Factory Calibration: Calibrate to NIST-traceable standards and provide a certificate of calibration for each transmitter.

D. Air-Pressure Transmitter, Differential Type - with Indicator and Round Face:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
3. Performance:
 - a. Range: Approximately **[2]<Insert value>** times set point.
 - b. Accuracy Including Hysteresis and Repeatability: Within 1 percent of full scale at **77 deg F (25 deg C)**.
 - c. Stability: Within 1 percent of full scale per year.
 - d. Overpressure: **10 psig (69 kPa)**.
 - e. Temperature Limits: **20 to 120 deg F (Minus 7 to plus 49 deg C)**.
 - f. Thermal Effects: 0.055 percent of full scale per degree F.
4. Display: Four-digit digital display with minimum **0.7-inch- (18-mm-)** high numeric characters.
5. Operator Interface:
 - a. Zero and span adjustments.
 - b. Selectable engineering units.
6. Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into a 1200-ohm load.
7. Construction:
 - a. Enclosure Face: Nominal **4-inch (100-mm)** diameter face.
 - b. Enclosure Material: Plastic casing with clear plastic cover.
 - c. Enclosure Rating: NEMA 250, Type 1.
 - d. Process Connections: Integral fittings for plastic tubing connections.
 - e. Wiring Connections: Terminal block.
 - f. Mounting: Vertical plane mounting.
 - g. Mounting Bracket: Appropriate for installation.
8. Factory Calibration: Calibrate to NIST-traceable standards and provide a certificate of calibration for each transmitter.

E. Air-Pressure Transmitter, Differential Type - with Indicator and Rectangular Face:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
 3. Performance:
 - a. Range: Approximately **[2]<Insert value>** times set point.
 - b. Accuracy including hysteresis and repeatability: Within 0.25 percent of full scale.
 - c. Stability: Within 1 percent of full scale per year.
 - d. Overpressure: Varies with range; at least 1.5 times range.
 - e. Temperature Limits: **Minus 4 to plus 158 deg F (Minus 20 to plus 70 deg C)**.
 4. Display: Digital with minimum **0.4-inch- (10-mm-)** high numeric characters.
 5. Operator Interface: Zero and span adjustments.
 6. Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into a 1200-ohm load.
 7. Construction:
 - a. Enclosure Material: Plastic.
 - b. Enclosure Rating: NEMA 250, Type 4X.
 - c. Process Connections: Integral barb fittings for plastic tubing connections.
 - d. Wiring Connections: Screw terminal block.
 - e. Mounting: Vertical plane mounting.
 - f. Mounting Bracket: Appropriate for installation.
 8. Factory Calibration: Calibrate to NIST-traceable standards and provide a certificate of calibration for each transmitter.
- F. Air-Pressure Transmitter, Differential Type - with Indicator and Field-Selectable Features:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Dwyer Instruments, Inc]
 - b. <Insert manufacturer's name>
3. Field-Selectable Features:
- a. Field configurable for pressure and velocity applications through user interface.
 - b. Field selectable from one of three pressure ranges both in SI (metric) and inch-pound (IP) units of measure.
 - c. Select range based on application. Range to be approximately [2]<Insert value> times set point.
4. Performance:
- a. Accuracy Including Hysteresis and Repeatability:
 - 1) Within 2 percent for **0.10 in. wg (25 Pa)**, **1.0 in. wg (250 Pa)** and all bidirectional ranges.
 - 2) Within 1 percent for other ranges.
 - b. Stability: Within 1 percent of full scale per year.
 - c. Response Time: Adjustable 0.5- to 15-second time constant with 95 percent response within 1.5 to 45 seconds.
 - d. Overpressure: **1 psig (6.9 kPa)** maximum operating; **10 psig (69 kPa)** burst pressure.
 - e. Temperature Limits: **Zero to 150 deg F (Minus 18 to plus 66 deg C)**.
5. Display: Four-digit digital display with minimum **0.4-inch- (10-mm-)** high numeric characters.
6. Operator Interface:
- a. Selectable pressure ranges, where indicated.
 - b. Zero and span adjustments.
 - c. Selectable air velocity mode with square root function.
 - d. Adjustable signal dampening
7. Output Signal:
- a. Analog Current Signal:
 - 1) Two-wire, 4 to 20 mA dc current source.
 - 2) Signal capable of operating into a 1200-ohm load.
 - b. Analog Voltage Signal:
 - 1) Three wire, zero to 10 V.
 - 2) Minimum Load Resistance: 1000 ohms.
8. Construction:
- a. Enclosure Face: Nominal **4-inch- (100-mm-)** diameter face.
 - b. Enclosure Material: Plastic.
 - c. Enclosure Rating: NEMA 250, Type 4X.
 - d. Process Connections: Plastic tubing connections on side of instrument case.
 - e. Conduit Connections: **1/2-inch (15-mm)** threaded connection for conduit.
 - f. Wiring Connections: Terminal block for wire connections.
 - g. Mounting: Vertical plane mounting.
 - h. Mounting Bracket: Appropriate for installation.

9. Factory Calibration: Calibrate to NIST-traceable standards and provide a certificate of calibration for each transmitter.
- G. Air-Pressure Transmitter, Differential Type - with 0.10 Percent Accuracy and Auto-Zero Feature:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **<Insert manufacturer's name>**
 3. Description: Smart transmitter receives static-pressure signals from a sensor (primary element), amplifies signals, and scales the signal to produce an output signal linear to pressure.
 - a. Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals to re-zero transmitter to within 0.1 percent of true zero.
 4. Performance:
 - a. Range: As required by application with range approximately **[2]<Insert value>** times set point.
 - b. Calibrated Span: Field adjustable, minus 40 percent of the range.
 - c. Accuracy: Within 0.10 percent of natural span.
 - d. Repeatability: Within 0.15 percent of calibrated span.
 - e. Linearity: Within 0.2 percent of calibrated span.
 - f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
 - g. Pressure: Surges of up to **25 psig (172 kPa)** will not harm transmitter.
 - h. Relative Humidity: 0 to 95 percent, noncondensing.
 - i. Temperature: **40 to 140 deg F (4 to 60 deg C)**.
 - j. Transmitter is to be shock and vibration tolerant without impacting performance.
 5. Output Signals:
 - a. Analog Outputs: Two outputs, individually configurable for 0 to 5 V dc, 0 to 10 V dc, or 4 to 20 mA.
 - b. Digital Outputs:
 - 1) Form C dry contacts rated for 3 A at 24 V ac/V dc for high and low alarms.
 - 2) Dual Form A dry contacts rated for 3 A at 24 V ac/V dc for auto-purge activation and acknowledgment.
 6. Network Communication: **[BACnet][or][Modbus TCP/IP]**.
 7. Construction:
 - a. Circuit Protection: Power input isolated, fused, and reverse polarity protected.
 - b. Display:

- 1) Integral backlit LCD digital display on face of enclosure; **[two][four]** lines of data display, with each line individually scalable in user selectable format and units of measure.
- 2) LED's indicate CPU activated, auto-zero in progress, auto-zero over-ranged, auto purge in progress, and auxiliary alarm "on" status.
- c. Noise Filter: Adjustable response time to reach 98 percent of a step change from 2 to 250 seconds.
- d. Enclosure Rating: NEMA 250, **[Type 1][or][Type 4]**.
- e. Process Connections: **[1/8-inch (3-mm)][1/4-inch (6-mm)]**<Insert size> metal compression fittings for field connection to tubing.
- f. Conduit Connections: Two trade-size conduit connections for connection to field-installed conduit.
- g. Wiring Connections: Labeled screw terminals concealed within enclosure.
8. Operator Interface: Transmitter configuration, parameter setting, zero and span calibration, plus display formatting and scaling performed digitally in the onboard microprocessor via input pushbuttons on face of enclosure.
9. Power: 24 V ac or V dc or 120 V ac via external transformer.
10. Factory Calibration: Calibrate to NIST-traceable standards and provide a certificate of calibration for each transmitter.

H. Air-Pressure Transmitter, Differential Type - with 0.25 Percent Accuracy and Auto-Zero Feature:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Monitor; an ONICON Brand]**
 - b. **<Insert manufacturer's name>**
3. Description: Smart transmitter receives static-pressure signals from a sensor (primary element), amplifies signals, and scales the signal to produce an output signal linear to pressure.
 - a. Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals to re-zero transmitter to within 0.1 percent of true zero.
4. Performance:
 - a. Range: As required by application with range approximately **[2]<Insert value>** times set point.
 - b. Calibrated Span: Field adjustable, minus 40 percent of the range.
 - c. Accuracy: Within 0.25 percent of natural span.
 - d. Repeatability: Within 0.15 percent of calibrated span.
 - e. Linearity: Within 0.2 percent of calibrated span.
 - f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.

- g. Pressure: Surges of up to **25 psig (172 kPa)** will not harm transmitter.
 - h. Relative Humidity: 0 to 95 percent, noncondensing.
 - i. Temperature: **40 to 140 deg F (4 to 60 deg C)**.
 - j. Transmitter is to be shock and vibration tolerant without impacting performance.
5. Output Signals:
- a. Analog Outputs: One output configurable for 0 to 5 V dc, 0 to 10 V dc, or 4 to 20 mA.
6. Construction:
- a. Circuit Protection: Power input isolated, fused, and reverse polarity protected.
 - b. Display: Integral backlit LCD digital display on face of enclosure for continuous indication of airflow.
 - c. Noise Filter: Adjustable response time to reach 98 percent of a step change from 2 to 250 seconds.
 - d. Enclosure Rating: NEMA 250, **[Type 1][Type 4][or][Type 12]**.
 - e. Process Connections: **[1/8-inch (3-mm)][1/4-inch (6-mm)][or][3/8-inch (9-mm)]<Insert size>** metal compression fittings for field connection to tubing.
 - f. Conduit Connections: Trade-size conduit connections to field-installed connection.
 - g. Wiring Connections: Labeled screw terminals concealed within enclosure.
7. Power: 24 V ac or V dc.
8. Factory Calibration: Calibrate to NIST-traceable standards and provide a certificate of calibration for each transmitter.

2.5 AIR-PRESSURE DIFFERENTIAL INDICATING TRANSMITTER, SWITCH, AND CONTROLLER

A. Air-Pressure Differential Indicating Transmitter, Switch, and Controller:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
- 3. Description:
 - a. Three-in-one instrument, including digital display, controller, control relay switches, and a transmitter with a current output.
 - b. Field configurable for pressure, velocity, and volumetric flow applications through user interface.
 - c. Select instrument range based on application. Range to be approximately **[2]<Insert value>** times set point.
- 4. Performance:

- a. Accuracy Including Hysteresis and Repeatability:
 - 1) Within 1.5 percent for ranges **0.25 in. wg (68 Pa)** and less.
 - 2) Within 1 percent for ranges **0.5 in. wg (125 Pa)** to **5 in. wg (1250 Pa)**.
 - 3) Within 0.5 percent at **77 deg F (25 deg C)** for other ranges.
 - b. Stability: Within 1 percent per year.
 - c. Response Time: 250 ms.
 - d. Overpressure: Varies with range; at least **[5]<Insert value>** times pressure range and not less than **1.5 psig (10 kPa)**.
 - e. Temperature Limits: **32 to 140 deg F (Zero to 60 deg C)**.
 - f. Compensated Temperature Limits: **32 to 140 deg F (Zero to 60 deg C)**.
 - g. Thermal Effects: 0.020 percent per degree F.
 - h. Warm-up Period: One hour.
5. Controller Programming through Menu Keys to Access Five Menus:
- a. Security level.
 - b. Pressure, velocity, or flow application.
 - c. Engineering units.
 - d. K-factor for use with flow application.
 - e. Set-point control only; set-point and alarm operation; and alarm operation as high, low, or high/low with manual or automatic reset and delay.
 - f. View high and low readings.
 - g. Digital dampening for smoothing erratic applications.
 - h. Scaling of analog output to fit range and field calibration.
6. Display:
- a. Digital, four-digit display with backlight, with **0.4-inch- (10-mm-)** high alphanumeric characters.
 - b. Four indicators; two for set point and two for alarm status.
7. Operator Interface:
- a. Set-point adjustment through keypad on face of instrument.
 - b. Zero and span adjustments accessible through menu.
 - c. Programming through keypad.
8. Analog Output Signal:
- a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into a 900-ohm load.
9. Digital Output Signal: Two SPDT relays, each rated for one amp at 30 V ac or dc.
10. Construction:
- a. Enclosure Face: Nominal **5-inch- (125-mm-)** diameter face.
 - b. Enclosure Material: Die-cast-aluminum casing and **[brushed Type 304 stainless steel]bezel**.
 - c. Enclosure Rating: NEMA 250, Type 1.
 - d. Process Connections: Threaded, **1/8-inch (3-mm)** NPT connections on side or back as required by application.
 - e. Mounting: Vertical plane mounting.
 - f. Mounting Bracket: Appropriate for installation.

11. Factory Calibration: Calibrate to NIST-traceable standards and provide each transmitter with a certificate of calibration.

2.6 LIQUID-PRESSURE SWITCHES

A. Liquid-Pressure Switch, Gauge-Pressure Type - Diaphragm Operated, Low Pressure:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Mercoïd Controls; a division of Dwyer Instruments, Inc.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Mercoïd Controls; a division of Dwyer Instruments, Inc.]**
 - b. **<Insert manufacturer's name>**
3. Description: Diaphragm operates to actuate an SPDT snap switch.
4. Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Performance:
 - a. Deadband: Fixed.
 - b. Operating Pressure Range: **[1 to 30 psig (7 to 207 kPa)][10 to 125 psig (69 to 862 kPa)]**.
 - c. Pressure Limits:
 - 1) Range 1 to 30 psig (7 to 207 kPa): **60 psig (414 kPa)**.
 - 2) Range 10 to 125 psig (69 to 862 kPa): **160 psig (1103 kPa)**.
 - d. Temperature Limits: **Minus 30 to plus 150 deg F (Minus 35 to plus 66 deg C)**.
 - e. Electrical Rating: 15 A at 120 V ac.
6. Operator Interface: External screw with visual set-point adjustment.
7. Construction:
 - a. Deadband: Fixed.
 - b. Enclosure:
 - 1) Dry Indoor Installations: NEMA 250, Type 1.
 - 2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
 - 3) Hazardous Environments: Explosion proof.
 - c. Diaphragm Material: **[Nylon reinforced Buna-N][or][PTFE]**.
 - d. Pressure Chamber Material: **[Steel][or][Stainless steel]**.
 - e. Process Connections: Threaded NPT, **1/4 inch (6 mm)**.
 - f. Conduit Connections: Knock out or threaded connection.
 - g. Wiring Connections: Screw terminal.

B. Liquid-Pressure Switch, Gauge-Pressure Type - Diaphragm Operated:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Mercoïd Controls; a division of Dwyer Instruments, Inc.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Mercoïd Controls; a division of Dwyer Instruments, Inc.]**
 - b. **<Insert manufacturer's name>**
3. Description: Diaphragm operates to actuate a **[SPDT][or][DPDT]** snap switch.
4. Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Performance:
 - a. Adjustable Operating Pressure Range: **[10 to 150 psig (69 to 1034 kPa)][20 to 250 psig (138 to 1724 kPa)][30 to 500 psig (207 to 3447 kPa)]**.
 - b. Pressure Limits: **1200 psig (8274 kPa)**.
 - c. Ambient Temperature Limits: **Minus 30 to plus 180 deg F (Minus 35 to plus 82 deg C)**.
 - d. Process Temperature Limits: **Minus 4 to plus 167 deg F (Minus 20 to plus 75 deg C)**.
 - e. Electrical Rating: 15 A at 120, 240, and 480 V ac.
6. Operator Interface: Internal hex nut set-point adjustment with enclosed and visible set-point indicator and scale.
7. Construction:
 - a. Deadband: Adjustable.
 - b. Enclosure:
 - 1) Dry Indoor Installations: NEMA 250, Type 4X.
 - 2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4X.
 - 3) Hazardous Environments: Explosion proof.
 - c. Pressure Chamber Material: **[Aluminum][or][stainless steel]**.
 - d. Diaphragm Material: **[Buna-N][or][fluorocarbon]**.
 - e. Process Connections: Threaded NPT, **1/2 inch (15 mm)**.
 - f. Conduit Connections: Threaded NPT, **3/4 inch (20 mm)**.
 - g. Wiring Connections: Screw terminal.

C. Liquid-Pressure Switch, Gauge-Pressure Type - Bourdon Tube Operated:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
3. Description:
- a. Bourdon tube operates to actuate a **[SPDT][or][DPDT]** snap switch as required for auto reset applications and SPST for manual reset applications.
 - b. Provide switches used in safety limiting applications with **[auto][manual]** reset.
4. Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Performance:
- a. Operating Pressure Range: Not less than system design pressure rating.
 - b. Pressure Limits: Equal to maximum pressure in full-scale range, but not less than system design pressure rating.
 - c. Temperature Limits: **180 deg F (82 deg C)**.
 - d. Electrical Rating: Minimum 10 A at 120/240 V ac.
6. Operator Interface: Thumbscrew set-point adjustment with visible enclosed set-point indicator and scale.
7. Construction:
- a. Deadband: **[Adjustable][Fixed][Adjustable or fixed as required by application]**.
 - b. Enclosure:
 - 1) Dry Indoor Installations: NEMA 250, Type 1.
 - 2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
 - 3) Hazardous Environments: Explosion proof.
 - c. Wetted Parts: **[Brass][Type 403 stainless steel][or][Type 316 stainless steel]**.
 - d. Process Connections: Threaded NPT, **1/4 inch (6 mm)**.
 - e. Conduit Connections: Knock out or threaded connection.
 - f. Wiring Connections: Screw terminal.
- D. Liquid-Pressure Switch, Differential Type - with Set-Point Indicator:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **<Insert manufacturer's name>**
 3. Description: Double opposing bellows operate to actuate a SPDT snap switch



4. Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Performance:
 - a. Operating Pressure Range: Approximately [2]<Insert value> times set point.
 - b. Pressure Limits: At least [5]<Insert value> times full-scale range, but not less than system design pressure rating.
 - c. Temperature Limits: **Minus 10 to plus 180 deg F (Minus 23 to plus 82 deg C).**
 - d. Electrical Rating: 15 A at 120 to 240 V ac.
6. Operator Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
7. Construction:
 - a. Deadband: [Adjustable][Fixed][Adjustable or fixed as required by application].
 - b. Bellows: [Brass][or][Type 316 stainless steel].
 - c. Enclosure:
 - 1) Dry Indoor Installations: NEMA 250, Type 1.
 - 2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
 - 3) Hazardous Environments: Explosion proof.
 - d. Process Connections: Threaded NPT, **1/8 inch (3 mm).**
 - e. Conduit Connections: Knock out or threaded connection.
 - f. Wiring Connections: Screw terminal.

E. Liquid-Pressure Switch, Differential Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Ashcroft Inc]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert **manufacturer's name; product name or designation**> or comparable product by one of the following:
 - a. [Ashcroft Inc]
 - b. <Insert manufacturer's name>
3. Description: Diaphragm operates to actuate an SPDT snap switch for auto reset applications and SPST for manual reset applications.
 - a. Provide switches used in safety limiting applications with [auto][manual] reset.
4. Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Performance:
 - a. Pressure Range: Approximately [2]<Insert value> times set point, unless otherwise required by application.
 - b. Pressure Limits: **Zero to 500 psig (Zero to 3447 kPa).**
 - c. Ambient Temperature Limits: **Minus 20 to plus 150 deg F (Minus 29 to plus 66 deg C).**

- d. Process Temperature Limits: **[20 to 150 deg F (Minus 7 to plus 66 deg C)][20 to 300 deg F (Minus 7 to plus 149 deg C)]**.
- e. Electrical Rating: 10 A at 120 to 240 V ac.
- 6. Operator Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
- 7. Construction:
 - a. Deadband: **[Adjustable][Fixed][Adjustable or fixed as required by application]**.
 - b. Enclosure Material: **[Aluminum][or][Stainless steel]**
 - c. Enclosure Rating: NEMA 250, Type 4 or 4X.
 - d. Seals: **[Buna-N][or][Viton]**.
 - e. Wetted Parts: Type 316 stainless steel.
 - f. Process Connections: Threaded NPT, **1/4 inch (6 mm)**.
 - g. Conduit Connections: Threaded connection.
 - h. Wiring Connections: Screw terminals.

2.7 LIQUID-PRESSURE TRANSMITTERS

A. Liquid Gauge Pressure Transmitter with Adjustable Span:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **<Insert manufacturer's name>**
- 3. Performance:
 - a. Pressure Range: **[Minus 300 to plus 300 psig (Minus 2068 to plus 2068 kPa)]<Insert pressure range>**.
 - b. Span: Field adjustable.
 - c. Minimum Span: **[2 psig (14 kPa)]<Insert pressure>**.
 - d. Accuracy: Within **[0.07]<Insert value>** percent of span or better.
 - e. Stability: Within **[0.125]<Insert value>** percent of upper range limit for **[5]<Insert value>** years.
 - f. Overpressure Limits: **[3626 psig (25000 kPa)]<Insert pressure>**.
 - g. Ambient Temperature Limits: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>**.
 - h. Process Temperature Limits: **[Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)]<Insert temperature range>**.
 - i. Temperature Effect: Within **[0.025]<Insert value>** percent of upper range limit plus **[0.125]<Insert value>** percent of span.
 - j. Transmitter is to be shock and vibration tolerant without impacting performance.
- 4. Analog Output Current Signal:

- a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into [1000]<Insert value>-ohm load.
 - c. Digital signal based on HART protocol carried with current signal.
 - d. Dampening: Field-selectable zero to [30]<Insert value> seconds.
 5. Operator Interface: Zero and span adjustments located behind removable cover.
 6. Display: Five-digit, two-line digital display with minimum **0.4-inch- (10-mm-)** high alphanumeric characters.
 7. Construction:
 - a. Enclosure: NEMA 250, Type 4X with removable cover on each side.
 - b. Nonwetted Parts: Aluminum or stainless steel.
 - c. Wetted Parts: Type 316 stainless steel.
 - d. Process Connections: [**NPS 1/2 (DN 15)**]<Insert size>.
 - e. Drain/vent valve on low- and high-pressure connections.
 - f. Conduit Connections: Two **1/2-inch (16-mm)** trade-size conduit connections with plugs on side of instrument enclosure.
 - g. Wiring Connections: Labeled screw terminal block.
 - h. Mounting Baskets: Include mounting brackets suitable for installation.
 8. Valve Manifold:
 - a. Furnish each transmitter with integrally mounted three-valve manifold.
 - b. Construction: Type 316 stainless steel.
 - c. Process Connections: Threaded NPT, **1/2 inch (16 mm)**.
 9. Factory Calibration: Calibrate each transmitter to NIST or other industry recognized traceable standards and provide a certificate of calibration for each transmitter.
- B. Liquid-Pressure Transmitter, Gauge-Pressure Type - with High Accuracy and Adjustable Span for Hazardous Environments:
1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. [**Rosemount; Emerson Electric Co., Automation Solutions**]
 - b. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert **manufacturer's name; product name or designation**> or comparable product by one of the following:
 - a. [**Rosemount; Emerson Electric Co., Automation Solutions**]
 - b. <Insert manufacturer's name>
 3. Hazardous Classification:
 - a. FM Approved for hazardous environments.
 - b. Intrinsically safe for Classes I, II, and III, Divisions 1 and 2, and Groups A through H.
 - c. Explosion-proof for Class I, Division 1, and Groups B, C, and D.
 - d. Dust-ignition-proof for Class II, Division 1, and Groups E, F, and G.
 - e. Dust-ignition-proof for Class III, Division 1.
 - f. <Insert requirements>.

4. Performance:
 - a. Pressure Range: **[Minus 300 to plus 300 psig (Minus 2068 to plus 2068 kPa)]<Insert pressure range>**.
 - b. Span: Field adjustable.
 - c. Minimum Span: **[2 psig (14 kPa)]<Insert pressure>**.
 - d. Accuracy: Within **[0.07]<Insert value>** percent of span or better.
 - e. Stability: Within **[0.125]<Insert value>** percent of upper range limit for **[5]<Insert value>** years.
 - f. Overpressure Limits: **[3626 psig (25000 kPa)]<Insert pressure>**.
 - g. Ambient Temperature Limits: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>**.
 - h. Process Temperature Limits: **[Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)]<Insert temperature range>**.
 - i. Temperature Effect: Within **[0.025]<Insert value>** percent of upper range limit plus **[0.125]<Insert value>** percent of span.
 - j. Transmitter is to be shock and vibration tolerant without impacting performance.
 5. Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into **[1000]<Insert value>**-ohm load.
 - c. Digital signal based on HART protocol carried with current signal.
 - d. Dampening: Field-selectable zero to **[30]<Insert value>** seconds.
 6. Operator Interface: Zero and span adjustments located behind removable cover.
 7. Display: Five-digit, two-line digital display with minimum **0.4-inch- (10-mm-)** high alphanumeric characters.
 8. Construction:
 - a. Enclosure: NEMA 250, Type 4X with removable cover on each side.
 - b. Nonwetted Parts: Aluminum or stainless steel.
 - c. Wetted Parts: Type 316 stainless steel.
 - d. Process Connections: **[NPS 1/2 (DN 15)]<Insert size>**.
 - e. Drain/vent valve on low- and high-pressure connections.
 - f. Conduit Connections: Two **1/2-inch (16-mm)** trade-size conduit connections with plugs on side of instrument enclosure.
 - g. Wiring Connections: Labeled screw terminal block.
 - h. Mounting Bracket: Include mounting brackets suitable for installation.
 9. Valve Manifold:
 - a. Furnish each transmitter with integrally mounted three-valve manifold.
 - b. Construction: Type 316 stainless steel.
 - c. Process Connections: Threaded NPT, **1/2 inch (16 mm)**.
 10. Factory Calibration: Calibrate each transmitter to NIST or other industry recognized traceable standards and provide a certificate of calibration for each transmitter.
- C. Liquid-Pressure Transmitter, Differential Type - with High Accuracy and Adjustable Span:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **<Insert manufacturer's name>**
3. Performance:
 - a. Pressure Range: **[Minus 300 to plus 300 psig (Minus 2068 to plus 2068 kPa)]<Insert pressure range>**.
 - b. Span: Field adjustable.
 - c. Minimum Span: **[2 psig (14 kPa)]<Insert pressure>**.
 - d. Accuracy: Within **[0.07]<Insert value>** percent of span or better.
 - e. Stability: Within **[0.125]<Insert value>** percent of upper range limit for **[5]<Insert value>** years.
 - f. Overpressure Limits: **[3626 psig (25000 kPa)]<Insert pressure>**.
 - g. Ambient Temperature Limits: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>**.
 - h. Process Temperature Limits: **[Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)]<Insert temperature range>**.
 - i. Temperature Effect: Within **[0.025]<Insert value>** percent of upper range limit plus **[0.125]<Insert value>** percent of span.
 - j. Transmitter is to be shock and vibration tolerant without impacting performance.
4. Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into **[1000]<Insert value>**-ohm load.
 - c. Digital signal based on HART protocol carried with current signal.
 - d. Dampening: Field-selectable zero to **[30]<Insert value>** seconds.
5. Operator Interface: Zero and span adjustments located behind removable cover.
6. Display: Five-digit, two-line digital display with minimum **0.4-inch- (10-mm-)** high alphanumeric characters.
7. Construction:
 - a. Enclosure: NEMA 250, Type 4X with removable cover on each side.
 - b. Nonwetted Parts: Aluminum or stainless steel.
 - c. Wetted Parts: Type 316 stainless steel.
 - d. Process Connections: **[NPS 1/2 (DN 15)]<Insert size>**.
 - e. Drain/vent valve on low- and high-pressure connections.
 - f. Conduit Connections: Two **1/2-inch (16-mm)** trade-size conduit connections with plugs on side of instrument enclosure.
 - g. Wiring Connections: Labeled screw terminal block.
 - h. Mounting Bracket: Include mounting brackets suitable for installation.
8. Valve Manifold:
 - a. Furnish each transmitter with integrally mounted five-valve manifold.
 - b. Construction: Type 316 stainless steel.
 - c. Process Connections: Threaded NPT, **1/2 inch (16 mm)**.

9. Factory Calibration: Calibrate each transmitter to NIST or other industry recognized traceable standards and provide a certificate of calibration for each transmitter.
- D. Liquid-Pressure Transmitter, Differential Type - with High Accuracy and Adjustable Span for Hazardous Environments:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b. **<Insert manufacturer's name>**
 3. Hazardous Classification:
 - a. FM Approved for hazardous environments.
 - b. Intrinsically safe for Classes I, II, and III, Divisions 1 and 2, and Groups A through H.
 - c. Explosion-proof for Class I, Division 1, and Groups B, C, and D.
 - d. Dust-ignition-proof for Class II, Division 1, and Groups E, F, and G.
 - e. Dust-ignition-proof for Class III, Division 1.
 - f. **<Insert requirements>**.
 4. Performance:
 - a. Pressure Range: **[Minus 300 to plus 300 psig (Minus 2068 to plus 2068 kPa)]<Insert pressure range>**.
 - b. Span: Field adjustable.
 - c. Minimum Span: **[2 psig (14 kPa)]<Insert pressure>**.
 - d. Accuracy: Within **[0.07]<Insert value>** percent of span or better.
 - e. Stability: Within **[0.125]<Insert value>** percent of upper range limit for **[5]<Insert value>** years.
 - f. Overpressure Limits: **[3626 psig (25000 kPa)]<Insert pressure>**.
 - g. Ambient Temperature Limits: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>**.
 - h. Process Temperature Limits: **[Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)]<Insert temperature range>**.
 - i. Temperature Effect: Within **[0.025]<Insert value>** percent of upper range limit plus **[0.125]<Insert value>** percent of span.
 - j. Transmitter is to be shock and vibration tolerant without impacting performance.
 5. Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into **[1000]<Insert value>**-ohm load.
 - c. Digital signal based on HART protocol carried with current signal.
 - d. Dampening: Field-selectable zero to **[30]<Insert value>** seconds.
 6. Operator Interface: Zero and span adjustments located behind removable cover.

7. Display: Five-digit, two-line digital display with minimum **0.4-inch- (10-mm-)** high alphanumeric characters.
8. Construction:
 - a. Enclosure: NEMA 250, Type 4X with removable cover on each side.
 - b. Nonwetted Parts: Aluminum or stainless steel.
 - c. Wetted Parts: Type 316 stainless steel.
 - d. Process Connections: **[NPS 1/2 (DN 15)]<Insert size>**.
 - e. Drain/vent valve on low- and high-pressure connections.
 - f. Conduit Connections: Two **1/2-inch (16-mm)** trade-size conduit connections with plugs on side of instrument enclosure.
 - g. Wiring Connections: Labeled screw terminal block.
 - h. Mounting Bracket: Include mounting brackets suitable for installation.
9. Valve Manifold:
 - a. Furnish each transmitter with integrally mounted five-valve manifold.
 - b. Construction: Type 316 stainless steel.
 - c. Process Connections: Threaded NPT, **1/2 inch (16 mm)**.
10. Factory Calibration: Calibrate each transmitter to NIST or other industry recognized traceable standards and provide a certificate of calibration for each transmitter.

E. Liquid-Pressure Transmitter, Differential Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Dwyer Instruments, Inc]**
 - b. **[Setra Systems Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dwyer Instruments, Inc]**
 - b. **[Setra Systems Inc.]**
 - c. **<Insert manufacturer's name>**
3. Performance:
 - a. Range: Approximately **[2]<Insert value>** times set point.
 - b. Span: Adjustable plus or minus one milliamp, noninteractive.
 - c. Accuracy: Within 0.25 percent of full-scale range.
 - d. Pressure: Maximum operating pressure **[2.5]<Insert value>** times range, but not less than system design pressure.
 - e. Temperature Limits: **Zero to 175 deg F (Minus 18 to plus 79 deg C)**.
 - f. Compensated Temperature Limits: **30 to 150 deg F (Minus 1 to plus 66 deg C)**.
 - g. Thermal Effects: 0.02 percent of full scale range per degree F.
 - h. Response Time: 30 to 50 ms.
 - i. Transmitter is to be shock and vibration tolerant without impacting performance.

4. Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into 1000-ohm load.
 5. Operator Interface:
 - a. Zero and span adjustments located on face or behind cover.
 - b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.
 6. Construction:
 - a. Enclosure: Aluminum and stainless steel enclosure with removable cover.
 - b. Enclosure NEMA Rating: NEMA 250, Type 4 or 4X.
 - c. Wetted Parts: Constructed of 17-4 PH or 300 Series stainless steel.
 - d. Process Connections: Threaded NPT, **1/4 inch (6 mm)**.
 - e. Conduit Connections: Knock out for **1/2-inch (16-mm)** nominal connections on side of instrument enclosure.
 - f. Wiring Connections: Screw terminal block.
 - g. Mounting Bracket: Appropriate for installation.
 7. Three-Valve Manifold:
 - a. Construction Materials: Brass, bronze, or stainless steel.
 - b. Process Connections: Threaded NPT, **1/4 inch (6 mm)**.
 8. Factory Calibration: Calibrate each transmitter to NIST or other industry recognized traceable standards and provide each transmitter with a certificate of calibration.
- F. Liquid-Pressure Transmitter, Differential Type - Single-Diaphragm Design:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Setra Systems Inc.]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Setra Systems Inc.]**
 - b. **<Insert manufacturer's name>**
 3. Performance:
 - a. Range: Approximately **[2]<Insert value>** times the set point.
 - b. Span: Adjustable within one milliamp, noninteractive.
 - c. Accuracy: Within 0.25 percent of full scale.
 - d. Hysteresis: Within 0.1 percent of full scale.
 - e. Repeatability: Within 0.05 percent of full scale.
 - f. Maximum Working Pressure: **250 psig (1724 kPa)**.
 - g. Temperature Limits: **Zero to plus 175 deg F (Minus 18 to plus 79 deg C)**.

- h. Compensated Temperature Limits: **30 to 150 deg F (Minus 1 to plus 66 deg C)**.
 - i. Thermal Effects: 0.02 percent of full scale per degree F.
 - j. Response Time: 30 to 50 ms.
 - k. Transmitter is to be shock and vibration tolerant without impacting performance.
 - 4. Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into 1000-ohm load.
 - 5. Analog Output Voltage Signal:
 - a. Three wire, zero to **[5][or][10] V**.
 - b. Minimum Load Resistance: 1000 ohms.
 - 6. Operator Interface:
 - a. Zero and span adjustments located behind cover.
 - b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.
 - 7. Construction:
 - a. Enclosure: Aluminum and stainless steel with removable cover.
 - b. Enclosure NEMA Rating: NEMA 250, Type 4.
 - c. Wetted Parts: Constructed of 17-4 PH or 300 Series stainless steel.
 - d. Process Connections: Threaded NPT, **1/4 inch (6 mm)**.
 - e. Conduit Connections: Knock out for **1/2-inch (15-mm)** nominal conduit connection on side of instrument enclosure.
 - f. Wiring Connections: Screw terminal block.
 - g. Mounting Bracket: Appropriate for installation.
 - 8. Valve Manifold: **[Three-][or][Five-]** valve design.
 - a. Construct manifold of brass, bronze, or stainless steel.
 - b. Process Connections: Threaded NPT, **1/4 inch (6 mm)**.
 - 9. Factory Calibration: Calibrate each transmitter to NIST or other industry recognized traceable standards and provide a certificate of calibration for each transmitter.
- G. Liquid-Pressure Transmitter, Differential Type - with Field-Selectable Range and Display:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Dwyer Instruments, Inc]**
 - b. **[Greystone Energy Systems, Inc.]**
 - c. **[Setra Systems Inc.]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Dwyer Instruments, Inc]**
 - b. **[Greystone Energy Systems, Inc.]**
 - c. **[Setra Systems Inc.]**
 - d. **<Insert manufacturer's name>**
3. Performance:
 - a. Field-Selectable Range:
 - 1) **5, 10, 25, and 50 psig (34, 69, 172, and 345 kPa).**
 - 2) **10, 20, 50, and 100 psig (69, 138, 345, and 689 kPa).**
 - 3) **25, 50, 125, and 250 psig (172, 345, 862, and 1724 kPa).**
 - b. Field-selectable unidirectional or bidirectional range.
 - c. Accuracy: Within 1 percent of the full-scale range, except lowest selectable range within 2 percent.
 - d. Stability: Within 0.5 percent of span per year.
 - e. Pressure: Maximum operating pressure equal to highest pressure in range, but not less than system design pressure.
 - f. Overpressure: Proof pressure 2 times full scale range; burst pressure **[20][40]** times full-scale range.
 - g. Ambient Temperature Limits: **[Minus 4 to plus 185 deg F (Minus 20 to plus 85 deg C)][32 to 122 deg F (0 to 50 deg C)]**.
 - h. Compensated Temperature Limits: **32 to 130 deg F (Zero to 54 deg C)**.
 - i. Thermal Effects: 2 percent of full scale per **100 deg F (56 deg C)**.
 - j. Response Time: Field selectable from 1 to **[5][60]** seconds.
 - k. Transmitter is to be shock and vibration tolerant without impacting performance.
4. Configurable Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into **[550][1000]**-ohm load.
5. Configurable Analog Output Voltage Signals:
 - a. Three wire, zero to 5 V, zero to 10 V[, and **1 to 5 V**].
 - b. Minimum Load Resistance: 1000 ohms.
6. Display: Four-digit LCD with minimum **0.4-inch- (10-mm-)** high numeric characters.
7. Operator Interface:
 - a. Digital zero button located behind cover.
 - b. Range selector located behind cover.
8. Construction:
 - a. Enclosure: Cast-aluminum enclosure with removable cover.
 - b. Enclosure NEMA Rating: NEMA 250, Type 4 or 4X.
 - c. Wetted Parts: Constructed of 17-4 PH stainless steel.
 - d. Process Connections: Threaded NPT, **1/8 inch (3 mm)**.
 - e. Conduit Connections: **1/2-inch (16-mm)** trade-size connection.
 - f. Wiring Connections: Screw terminal block.
 - g. Mounting: Vertical plane mounting.
 - h. Mounting Bracket: Appropriate for installation.
9. Three-Valve Manifold:

- a. Construction Materials: Brass, bronze, or stainless steel.
- b. Process Connections: Threaded NPT.

10. Factory Calibration: Calibrate each transmitter to NIST-traceable standards and provide a certificate of calibration for each transmitter.

H. Liquid-Pressure Transmitter, Differential Type - 1 Percent Accuracy:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. **[MAMAC Systems, Inc.]**
- b. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[MAMAC Systems, Inc.]**
- b. **<Insert manufacturer's name>**

3. Performance:

- a. Range: Approximately **[2]<Insert value>** times set point.
- b. Accuracy: Within 1 percent of the full-scale range.
- c. Overpressure: Proof pressure 3 times full-scale range, burst pressure 5 times full-scale range.
- d. Compensated Temperature Limits: **Zero to 180 deg F (Minus 18 to plus 82 deg C).**
- e. Thermal Effects: 0.025 percent of full scale per degree F.
- f. Transmitter is to be shock and vibration tolerant without impacting performance.

4. Analog Output Current Signal:

- a. Two-wire, 4 to 20 mA dc current source.
- b. Signal capable of operating into 1000-ohm load.

5. Analog Output Voltage Signals:

- a. Three wire, field selectable from zero to 5 V or zero to 10 V.
- b. Minimum Load Resistance: 1000 ohms.

6. Construction:

- a. Enclosure: Corrosion-resistant steel with baked-enamel finish and removable front cover.
- b. Enclosure NEMA Rating: NEMA 250, Type 1.
- c. Wetted Parts: Constructed of stainless steel.
- d. Process Connections: Threaded NPT, **1/8-inch (3-mm).**
- e. Conduit Connections: **1/2-inch (16 mm)** trade-size conduit on side of instrument enclosure.
- f. Wiring Connections: Screw terminal block.
- g. Vertical plane mounting.
- h. Mounting Bracket: Appropriate for installation.

2.8 ROOM PRESSURE MONITORS

A. Room Pressure Monitor, Multifunction - Isolated Pressure Measurement Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Critical Room Control]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Setra Systems Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Critical Room Control]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Setra Systems Inc.]**
 - d. **<Insert manufacturer's name>**
3. General:
 - a. Integral self-diagnostics to ensure unit is operating properly.
 - b. Save parameters and settings in nonvolatile memory.
 - c. Field configurable, without need for commissioning tools, through easy-to-use and intuitive display menus.
 - d. Positive, negative, no (neutral) and vacant (stand-by) pressurization modes set using touchscreen display.
 - e. Pressurization modes remotely switchable through remote control system interface.
 - f. Multiple levels of password protection to provide secure access to functions.
4. Mounting: Recessed in wall, unless otherwise indicated.
5. Monitoring and Control:
 - a. Field configurable for monitoring and display only, or for monitoring, display and integral control.
 - 1) Monitoring and Display: Room pressure differential, temperature, relative humidity[, **room air-change rate**][and][**operator (user)-defined parameters indicated**].
 - 2) Control: Room pressure differential, room temperature[, **room relative humidity**].
 - b. Pressure Differential:
 - 1) Inputs: 0 to 5 V, 0 to 10 V, or 4 to 20 mA or serial communication signal from network.
 - 2) Output: 0 to 5 V or 0 to 10 V analog signal for remote monitoring by control system.
 - 3) Integral and field-tunable **[PI][or][PID]** control function where standalone operation is indicated.
 - c. Temperature:
 - 1) Inputs: 0 to 5 V, 0 to 10 V, or 4 to 20 mA or serial communication signal from control system.

- 2) Output: 0 to 5 V or 0 to 10 V analog signal for temperature control.
 - 3) Integral and field-tunable **[PI]****[or]****[PID]** control function where standalone operation is indicated.
 - d. Relative Humidity:
 - 1) Inputs: 0 to 5 V, 0 to 10 V, or 4 to 20 mA or serial communication signal from control system.
 - 2) Output: 0 to 5 V, 0 to 10 V analog signal for humidity control.
 - 3) Integral and field-tunable **[PI]****[or]****[PID]** control function where standalone operation is indicated.
 - e. Room Air-Change Rate (ACH):
 - 1) Inputs: 0 to 5 V, 0 to 10 V, or 4 to 20 mA or serial communication signal from control system for ACH or perform ACH calculation from input signal of room airflow.
 - f. Operator (User)-Defined Parameter(s).
 - 1) **<Insert requirements>**.
6. Color Touchscreen Display:
- a. Screen Size: Nominal **[6-inch (150-mm)]****[or]****[7-inch (175-mm)]****<Insert size>**.
 - b. Complete word text with graphics and color indication of pressure differential operating condition and room status. Colors indicated are preferred. Other colors are acceptable so long as a unique color is used for each different condition/status.
 - 1) Green for "Normal" status.
 - 2) Orange for "Warning" status.
 - 3) Red for "Alarm" status.
 - 4) Blue for "Vacant" or "Stand-by" status.
 - c. Highly visible and readable in direct sunlight.
 - d. Operator interaction with screen through bare finger, gloved finger, or stylus.
 - e. Two separate levels of field-changeable password-protected operator access.
 - f. Alphanumeric display of room name and number.
 - g. Pressure differential display with resolution to at least four decimal places.
 - h. Onscreen ability to:
 - 1) Silence audible alarms.
 - 2) Manually zero calibrate pressure measurement with a single touch.
 - 3) Display and hide room temperature and temperature set point.
 - 4) Display and hide room relative humidity and relative humidity set point.
 - 5) Change temperature set point.
 - 6) Change relative humidity set point.
 - 7) Display and hide room air-change rate.
 - 8) Change display units of measure between IP and SI.
7. Pressure Differential Transducer:
- a. Room monitor to house a pressure differential transducer with two pressure ports for connection to remotely mounted space pressure sensors.
 - 1) Install one space pressure sensor in room being monitored and the other space

- pressure sensor in the reference space.
 - 2) Maintain complete isolation of each room pressure measurement to prevent possible contamination between the two spaces.
 - b. High-end, industrial-grade instrument with long-term accuracy and stability.
 - c. Accuracy: Within **[0.1][0.25]<Insert value>** percent of the full-scale range.
 - d. Full Scale Pressure Range: Select for specific application with bidirectional full-scale range approximately **[2]<Insert value>** times room pressure differential control set point.
 - e. Overpressure: Up to **[1 psig (7 kPa)][5 psig (35 kPa)]<Insert pressure>** without damage.
 - f. Factory Calibration: Provide NIST-traceable calibration certificate for each transducer.
- 8. Digital Inputs:
 - a. Door position contacts.
 - b. Room occupancy contacts.
 - c. Remote silence of audible alarm.
 - d. Airflow alarm.
 - e. Operator (User)-Defined Parameter(s): **<Insert requirement>**.
- 9. Digital Outputs:
 - a. Normally open relays rated for up to 12 V at 500 mA.
 - b. Separate output signals:
 - 1) Pressure alarm indication.
 - 2) Temperature alarm indication.
 - 3) Airflow alarm indication.
 - 4) Audible alarm indication.
- 10. Control System Communication Interface:
 - a. Interface to Any of following: BACnet IP, BACnet MS/TP, LON, or Modbus.
 - b. Provide interface required by control system.
- 11. Alarming:
 - a. Independent high and low audible and visual alarms.
 - b. Adjustable time delay for audible and visual alarms.
 - c. Unique and distinct sound for pressure and remote alarms.
- B. Room Pressure Monitor, Multifunction Thermal Measurement Type:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[TSI Incorporated]**
 - b. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[TSI Incorporated]**
 - b. **<Insert manufacturer's name>**

3. General:
 - a. Integral self-diagnostics to ensure unit is operating properly.
 - b. Save parameters and settings in nonvolatile memory.
 - c. Field configurable, without need for commissioning tools, through easy-to-use and intuitive display menus.
 - d. Positive, negative, no (neutral), and vacant (stand-by) pressurization modes set using touchscreen display.
 - e. Pressurization modes remotely switchable through remote control system interface.
 - f. Multiple levels of password protection to provide secure access to functions.
4. Mounting: Recessed in wall, unless otherwise indicated.
5. Monitoring and Control:
 - a. Field configurable for monitoring and display only, or for monitoring, display and integral control.
 - 1) Monitoring and Display: Room pressure differential, temperature, relative humidity[**and room air-change rate**].
 - 2) Control: Room pressure differential, room temperature[**and room relative humidity**].
 - b. Pressure Differential:
 - 1) Inputs: 0 to 10 V or 4 to 20 mA or serial communication signal from network.
 - 2) Output: 0 to 10 V analog signal for remote monitoring by control system.
 - 3) Integral and field-tunable **[PI][or][PID]** control function where standalone operation is indicated.
 - c. Temperature:
 - 1) Inputs: 0 to 10 V or 4 to 20 mA or serial communication signal from control system.
 - 2) Output: 0 to 10 V analog signal for temperature control.
 - 3) Integral and field-tunable **[PI][or][PID]** control function where standalone operation is indicated.
 - d. Relative Humidity:
 - 1) Inputs: 0 to 10 V or 4 to 20 mA or serial communication signal from control system.
 - e. Room Air-Change Rate (ACH):
 - 1) Inputs: 0 to 10 V or 4 to 20 mA or serial communication signal from control system for ACH or perform ACH calculation from input signal of room airflow.
6. Color Touchscreen Display:
 - a. Screen Size: Nominal **5-inch (125-mm)**.
 - b. Complete word text with graphics and color indication of pressure differential operating condition and room status. Colors indicated are preferred. Other colors are acceptable so long as a discreet color is used for each different condition.
 - 1) Green for "Normal" status.
 - 2) Orange for "Warning" status.
 - 3) Red for "Alarm" status.

- 4) Blue for "Vacant" or "Stand-by" status.
- c. Highly visible and readable in direct sunlight.
- d. Operator interaction with screen through bare finger, gloved finger, or stylus.
- e. Alphanumeric display of room name and number.
- f. Pressure differential display with resolution to at least four decimal places.
- g. Onscreen ability to:
 - 1) Silence audible alarms.
 - 2) Manually zero calibrate pressure measurement with a single touch.
 - 3) Display and hide room temperature and temperature set point.
 - 4) Display and hide room relative humidity and relative humidity set point.
 - 5) Change temperature set point.
 - 6) Change relative humidity set point.
 - 7) Display and hide room air-change rate.
 - 8) Change display units of measure between IP and SI.
- 7. Pressure Differential Measurement:
 - a. Bidirectional through-the-sensor using thermal measurement technology.
 - b. Performance:
 - 1) Accuracy: Within 10 percent of actual pressure reading over a range of **negative 0.2 to positive 0.2 inch wg (negative 50 to positive 50 Pa)**.
 - 2) Resolution: Within 5 percent of actual reading.
 - 3) Temperature Compensation: **55 to 95 deg F (13 to 35 deg C)**.
 - c. Factory Calibration: Provide sensor with a NIST-traceable calibration certificate.
- 8. Digital Inputs:
 - a. Door position contacts.
 - b. Room occupancy contacts.
 - c. Remote silence of audible alarm.
 - d. Airflow alarm.
- 9. Digital Outputs:
 - a. Normally open relays.
 - b. Separate output signals:
 - 1) High-pressure alarm indication.
 - 2) Low-pressure alarm indication.
- 10. Control System Communication Interface:
 - a. Interface to Any of following: BACnet MS/TP, LONworks, or Modbus.
 - b. Provide interface required by control system.
- 11. Alarming:
 - a. Independent high and low audible and visual alarms.
 - b. Adjustable time delay for audible and visual alarms.
 - c. Unique and distinct sound for pressure and remote alarms.

2.9 SOURCE QUALITY CONTROL

- A. Factory Tests and Inspections: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.
- B. Prepare test and inspection reports as applicable.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping systems to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PRESSURE INSTRUMENT APPLICATIONS

- A. Air-Pressure Sensors:
 - 1. Air-Pressure Sensor, Static Pressure Duct Insertion Type - 90-Degree Probe Design with Compression Fitting Connection: **<Insert system><Insert unique application>**.
 - 2. Air-Pressure Sensor, Static Pressure Duct Insertion Type - 90-Degree Probe Design with Barb Connection: **<Insert system><Insert unique application>**.
 - 3. Air-Pressure Sensor, Static Pressure Duct Insertion Type - Straight Probe with Barb Connection: **<Insert system><Insert unique application>**.
 - 4. Air-Pressure Sensor, Static Pressure Duct Insertion Type - Dual-Orifice Design: **<Insert system><Insert unique application>**.
 - 5. Air-Pressure Sensor, Static Pressure Duct Traverse Type: **<Insert system><Insert unique application>**.
 - 6. Air-Pressure Sensor, Static Pressure, Outdoor Type : **<Insert system><Insert unique application>**.
 - 7. Air-Pressure Sensor, Static Pressure Outdoor Type - NEMA 250, Type 4X Enclosure: **<Insert system><Insert unique application>**.
 - 8. Air-Pressure Sensor, Static Pressure Outdoor Type - Unaffected/Unimpaired by Rain and Snow: **<Insert system><Insert unique application>**.
 - 9. Air-Pressure Sensor, Static Pressure Space Type for Wall Mounting - Stainless Steel Wall Plate: **<Insert system><Insert unique application>**.
 - 10. Air-Pressure Sensor, Static Pressure Space Type for Wall Mounting - ABS Plastic Wall Plate: **<Insert system><Insert unique application>**.
 - 11. Air-Pressure Sensor, Static Pressure Space Type with Published Performance for Wall Mounting: **<Insert system><Insert unique application>**.
 - 12. Air-Pressure Sensor, Static Pressure Space Type with Published Performance for Recessed Ceiling Mounting: **<Insert system><Insert unique application>**.

13. Air-Pressure Sensor, Static Pressure Space Type with Published Performance for Exposed or Suspended Ceiling Mounting: **<Insert system><Insert unique application>**.
- B. Air-Pressure Switches:
1. Air-Pressure Switch, Differential Type: **<Insert system><Insert unique application>**.
 2. Air-Pressure Switch, Differential Type - with Set-Point Indicator: **<Insert system><Insert unique application>**.
 3. Air-Pressure Switch, Differential Type - with Dual-Scale Adjustable Set Point: **<Insert system><Insert unique application>**.
 4. Air-Pressure Switch, Differential Type - with Indicator: **<Insert system><Insert unique application>**.
- C. Air-Pressure Transmitters:
1. Air-Pressure Transmitter, Differential Type - with Display: **<Insert system><Insert unique application>**.
 2. Air-Pressure Transmitter, Differential Type: **<Insert system><Insert unique application>**.
 3. Air-Pressure Transmitter, Differential Type - for Hazardous Environments: **<Insert system><Insert unique application>**.
 4. Air-Pressure Transmitter, Differential Type - with Indicator and Round Face: **<Insert system><Insert unique application>**.
 5. Air-Pressure Transmitter, Differential Type - with Indicator and Rectangular Face: **<Insert system><Insert unique application>**.
 6. Air-Pressure Transmitter, Differential Type - with Field-Selectable Features: **<Insert system><Insert unique application>**.
 7. Air-Pressure Transmitter, Differential Type - with 0.10 Percent Accuracy and Auto-Zero Feature: **<Insert system><Insert unique application>**.
 8. Air-Pressure Transmitter, Differential Type - with 0.25 Percent Accuracy and Auto-Zero Feature: **<Insert system><Insert unique application>**.
- D. Air-Pressure Three-in-One Combination Controller/Switch/Transmitters:
1. Air-Pressure Three-in-One Combination Controller/Switch/Transmitter, Differential Type - with Indicator: **<Insert system><Insert unique application>**.
- E. Liquid-Pressure Switches:
1. Liquid-Pressure Switch, Gauge-Pressure Type - Diaphragm Operated, Low Pressure: **<Insert system><Insert unique application>**.
 2. Liquid-Pressure Switch, Gauge-Pressure Type - Diaphragm Operated: **<Insert system><Insert unique application>**.
 3. Liquid-Pressure Switch, Gauge-Pressure Type - Bourdon Tube Operated: **<Insert system><Insert unique application>**.
 4. Liquid-Pressure Switch, Differential Type - with Set-Point Indicator: **<Insert system><Insert unique application>**.
 5. Liquid-Pressure Switch, Differential Type: **<Insert system><Insert unique application>**.
 6. Liquid-Pressure Transmitter, Gauge-Pressure Type - with High Accuracy and Adjustable Span: **<Insert system><Insert unique application>**.
 7. Liquid-Pressure Transmitter, Gauge-Pressure Type - with High Accuracy and Adjustable Span for Hazardous Environments: **<Insert system><Insert unique application>**.
 8. Liquid-Pressure Transmitter, Differential Type - with High Accuracy and Adjustable Span: **<Insert system><Insert unique application>**.
 9. Liquid-Pressure Transmitter, Differential Type - with High Accuracy and Adjustable Span for Hazardous Environments: **<Insert system><Insert unique application>**.
 10. Liquid-Pressure Transmitter, Differential Type: **<Insert system><Insert unique application>**.



11. Liquid-Pressure Transmitter, Differential Type - Single-Diaphragm Design: **<Insert system><Insert unique application>**.
12. Liquid-Pressure Transmitter, Differential Type with Field-Selectable Range and Display: **<Insert system><Insert unique application>**.
13. Liquid-Pressure Transmitter, Differential Type - 1 Percent Accuracy: **<Insert system><Insert unique application>**.

F. Room Pressure Monitors:

1. Room Pressure Monitors, Multifunction - Isolated Pressure Measurement Type: **<Insert unique application>**.
2. Room Pressure Monitors, Multifunction - Thermal Measurement Type: **<Insert unique application>**.

3.3 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment.
- C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- D. Fastening Hardware:
1. Wrenches, pliers, and other tools that cause damage to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- F. Corrosive Environments:
1. Use products that are suitable for environment to which they are subjected.
 2. Avoid or limit use of materials in corrosive environments.
 3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 INSTALLATION OF PRESSURE INSTRUMENTS

- A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
 2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
 3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
 6. Install instruments (except pressure gauges) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of **[2][3]<Insert value>** percent.
 7. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of **[2][3]<Insert value>** percent.
- B. Mounting Height:
1. Mount remote displays, switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of **42 to 72 inches (1050 to 1800 mm)** above the adjacent floor, grade, or service catwalk or platform.
 - a. Mount at **60 inches (1500 mm)**.
- C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
- D. Duct Pressure Sensors:
1. Install sensors using manufacturer's recommended upstream and downstream distances.
 2. Unless indicated on Drawings, locate sensors approximately **[50][67][75]** percent of distance of longest hydraulic run. Location of sensors is to be submitted and approved before installation.
 3. Install mounting hardware and gaskets to make sensor installation airtight.
 4. Route tubing from the sensor to transmitter.
 5. Use compression fittings at terminations.
 6. Install sensor in accordance with manufacturer's instructions.
 7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.
- E. Outdoor Pressure Sensors:
1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
 2. Locate wall-mounted sensor in an inconspicuous location.
 3. Submit sensor location for approval before installation.
 4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
 5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.

6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

F. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route **NPS 3/8 (DN 12)** tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within **[50 ft. (15 m)]<Insert distance>**; otherwise, locate switch in vicinity of system connection.

G. Liquid-Pressure Switches:

1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.
3. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single location for inspection and service.
4. System process tubing connection to be full size of switch connection, but not less than **[NPS 1/2 (DN 15)][NPS 3/4 (DN 20)][NPS 1 (DN 25)]<Insert option>**. Install **[stainless steel]** bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to switch.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each switch connection.
8. Do not mount switches on rotating equipment.
9. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
10. Install switches in an easily accessible location serviceable from floor.

H. Liquid-Pressure Transmitters:

1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection to be full size of switch connection, but not less than **[NPS 1/2 (DN 15)][NPS 3/4 (DN 20)][NPS 1 (DN 25)]<Insert option>**. Install **[stainless steel]** bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to transmitter.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each transmitter connection.
8. Do not mount transmitters on equipment.
9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage

and hinder accurate operation.

3.5 ELECTRIC POWER

- A. Provide electrical power to products requiring electrical connections.
- B. Provide power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Provide raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."
- E. Provide circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by instrument manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate at each instrument electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplates are to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplates are to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Provide raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."

3.7 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification[**and on face of ceiling directly below instruments concealed above ceilings**].

3.8 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials

from exposed interior and exterior surfaces.

3.9 CHECKOUT PROCEDURES

- A. Check out installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.
- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

- 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
- 2. Submit a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
- 3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
- 4. Equipment and procedures used for calibration must comply with instrument manufacturer's recommendations.
- 5. Furnish diagnostic and test equipment for calibration and adjustment.
- 6. Field instruments and equipment used to test and calibrate installed instruments to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent is to be checked by an instrument with an accuracy of 0.5 percent.
- 7. Calibrate each instrument in accordance with instrument instruction manual supplied by manufacturer.
- 8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
- 9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

- 1. Check analog voltage signals using a voltage meter at zero, 50, and 100 percent.
- 2. Check analog current signals using a current meter at zero, 50, and 100 percent.

C. Digital Signals:

- 1. Check digital signals using a jumper wire.
- 2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of project design values. **[Field calibration is not required for instruments that have been factory calibrated and provided with certificates.]**

3.11 ADJUSTING

- A. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.12 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes **[three][six][nine][12]** months' full maintenance by **[skilled employees of systems and equipment Installer][manufacturer's authorized service representative]**. Include **[monthly][quarterly][semiannual][annual]** preventive maintenance, repair or replacement of worn or defective components, cleaning, lubrication and adjusting as required for proper operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

3.13 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 09 23 23



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 23 23	23 09 23 00	Direct Digital Control (DDC) System for HVAC
23 09 23 23	23 09 23 00a	Leak Detection Instruments
23 09 23 23	23 09 23 00b	Position Instruments
23 09 23 23	23 09 00 00	Speed Instruments
23 09 23 23	23 09 23 00c	Sequence of Operations for HVAC DDC



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 09 23 27 - TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air temperature sensors.
2. Air temperature sensors with network communication signal.
3. Multivariable air temperature sensors and transmitters.
4. Wireless air temperature sensors.
5. Combination air temperature sensors and switches.
6. Air temperature switches.
7. Air temperature RTD transmitters.
8. Liquid and steam temperature sensors.
9. Strap-on temperature sensors for piping.
10. Liquid temperature switches.
11. Liquid and steam temperature transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993.11 "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

1.2 DEFINITIONS

- A.** HART (Highway Addressable Remote Transducer) Protocol: The global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bidirectional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from a technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.
- B.** PIR: Passive infrared.
- C.** RTD: Resistance temperature detector.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For the following:
 - a. Air temperature sensors.
 - b. Air temperature sensors with network communication signal.
 - c. Multi-variable air temperature sensors and transmitters.
 - d. Wireless air temperature sensors.

- e. Combination air temperature sensors and switches.
 - f. Air temperature switches.
 - g. Air temperature RTD transmitters.
 - h. Liquid and steam temperature sensors.
 - i. Strap-on temperature sensors for piping.
 - j. Liquid temperature switches.
 - k. Liquid and steam temperature transmitters.
2. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 3. Operating and performance characteristics, electrical characteristics, functional characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including pressure, temperature, and humidity.
 4. Product description with complete technical data, performance curves, and product specification sheets.
 5. Installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and[**mounting**] details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Samples: For each exposed product installed in finished space.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades:

1. Product installation location shown in relationship to room, duct, pipe, and equipment.
2. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
3. Sizes and locations of wall access panels for instruments installed behind walls.
4. Sizes and locations of ceiling access panels for instruments installed in inaccessible ceilings.

B. Product Certificates: For each product requiring a certificate.

C. Product Test Reports: For **[air temperature sensors][air temperature sensors with network communication signal][multivariable air temperature sensors][wireless air temperature sensors][combination air temperature sensors and switches][air temperature switches][air temperature RTD transmitters][liquid and steam temperature sensors, commercial grade][liquid and steam temperature sensors, high-end commercial grade][liquid and steam temperature switches, industrial grade][liquid temperature switches, commercial grade][liquid temperature switches, high-end commercial grade][liquid temperature switches, industrial grade]**, for tests performed by **[manufacturer and witnessed by a qualified testing agency][a qualified testing agency]**.

- D. Source quality-control reports.
- E. Field quality-control reports.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Provide **[one][two]<Insert quantity>** matching product(s) in Project inventory for each unique type of the following:
 - 1. **<Insert product>**.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Environmental Conditions:
 - 1. Instruments are to operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure is to be internally insulated, electrically heated **[and cooled]**, filtered, and ventilated as required by instrument and application.
 - 2. Instruments and accessories are to be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated are to be housed in protective secondary enclosures. Instrument's installed location is to dictate NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: **[Type 2][Type 3][or][Type 12]<Insert type>**.
 - b. Outdoors, Unprotected: **[Type 4][or][Type 4X]<Insert type>**.
 - c. Indoors, Heated with Filtered Ventilation: **[Type 1][or][Type 2]<Insert type>**.
 - d. Indoors, Heated with Nonfiltered Ventilation: **[Type 2][or][Type 12]<Insert type>**.
 - e. Indoors, Heated and Air Conditioned: **[Type 1]<Insert type>**.
 - f. Mechanical Equipment Rooms:
 - 1) Chiller and Boiler Rooms: **[Type 12][Type 4][or][Type 4X]<Insert type>**.
 - 2) Air-Moving Equipment Rooms: **[Type 1][Type 2][or][Type 12]<Insert type>**.
 - g. Localized Areas Exposed to Washdown: **[Type 4][or][Type 4X]<Insert type>**.
 - h. Within Duct Systems and Air-Moving Equipment not Exposed to Possible Condensation: **[Type 2][Type 3][Type 4][or][Type 12]<Insert type>**.
 - i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: **[Type 4][or][Type 4X]<Insert type>**.
 - j. Hazardous Locations: Explosion-proof rating for condition.
 - k. **<Insert location and enclosure requirements>**.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTD, Single-Point Duct Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**
 - i. **[Minco]**
 - j. **[Schneider Electric USA, Inc.]**
 - k. **[Siemens Industry, Inc., Building Technologies Division]**
 - l. **[Vaisala]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**
 - i. **[Minco]**
 - j. **[Schneider Electric USA, Inc.]**
 - k. **[Siemens Industry, Inc., Building Technologies Division]**
 - l. **[Vaisala]**
 - m. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all platinum RTD single-point air temperature duct sensors from a single manufacturer.
4. Factory Calibration: Factory calibrate each instrument to **[NIST-]**traceable standards and include instrument with a calibration certificate.
5. Performance:
 - a. Repeatability: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>**.
 - b. Self-Heating: Negligible.
 - c. Two- or three-wire, PTFE-insulated, minimum 22-gauge stranded copper leads.
 - d. Resistance: **[100 ohms][or][1000 oms][100 or 1000 ohms as indicated for each application under Part 3 or on the Drawings]**.
 - e. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/deg C.
 - f. Temperature Range: As required by application, not less than **[Minus 40 to 185 deg F (Minus 45 to 85 deg C)][Minus 50 to 275 deg F]**

- (Minus 45 to 135 deg C)][Minus 40 to 392 deg F (Minus 40 to 200 deg C)]<Insert temperature range>.
- g. Accuracy: At 32 deg F (0 deg C) within [0.27 deg F (0.15 deg C)][0.54 deg F (0.3 deg C)][0.27 deg F (0.15 deg C) or 0.54 deg F (0.3 deg C) as required by application]<Insert temperature>.
6. Output Signal: Resistance in ohms.
 7. Sensor Assembly:
 - a. Probe: Single-point RTD wired within a rigid stainless steel sheath.
 - b. Length: As required by application to achieve probe tip near midpoint of air tunnel, up to **18 inches (450 mm)** long.
 8. Enclosure:
 - a. Material: Metal[**or plastic**] box with removable cover.
 - b. Rating: NEMA 250, [Type 1][Type 3R][Type 4][or][Type 4X]<Insert type> for indoor applications and [Type 4][or][Type 4X]<Insert type> for outdoor applications.
 - c. Field Wiring Connection: Terminal block.
 - d. Conduit Connection: **1/2-inch (16-mm)[or 3/4-inch (20-mm)]** trade size.
 9. Gasket: For attachment to duct or equipment to seal penetration airtight.
- B. Platinum RTD, Averaging Air Temperature Sensors:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Minco]
 - j. [Schneider Electric USA, Inc.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Minco]



- j. **[Schneider Electric USA, Inc.]**
 - k. **[Siemens Industry, Inc., Building Technologies Division]**
 - l. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all platinum RTD air temperature averaging sensors from a single manufacturer.
 4. Factory Calibration: Factory calibrate each instrument to **[NIST-]**traceable standards and include instrument with a calibration certificate.
 5. Description: Multiple internal RTDs located across length of sensor probe and internally wired to signal a single average temperature reading.
 6. Two- or three-wire, PTFE-insulated, minimum 22-gauge stranded copper leads.
 7. Performance:
 - a. Repeatability: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>**.
 - b. Self-Heating: Negligible.
 - c. Resistance: **[100 ohms][or][1000 ohms][100 or 1000 ohms as indicated for each application under Part 3 or on the Drawings]**.
 - d. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/deg C.
 - e. Temperature Range: As required by application, not less than **[Minus 40 to 185 deg F (Minus 40 to 85 deg C)][Minus 50 to 275 deg F (Minus 45 to 135 deg C)]<Insert temperature range>**.
 - f. Accuracy: At **32 deg F (0 deg C)** within **[0.54 deg F (0.3 deg C)]<Insert temperature>**.
 8. Output Signal: Resistance in ohms.
 9. Sensor Probe:
 - a. Type: Flexible probes; option to use averaging rigid probe sensors for air tunnels up to **[20 inches (500 mm)][36 inches (900 mm)]<Insert distance>**.
 - b. Material:
 - 1) Flexible Probe: **[Aluminum][Brass][Copper][or][stainless steel]<Insert material>**.
 - 2) Rigid Probe: **[Stainless steel]<Insert material>**
 - c. Flexible probes formable to a minimum **[4-inch (100-mm)]<Insert distance>** radius.
 - d. Length: As required by application to account for temperature variations across entire cross section of air tunnel.
 10. Enclosure:
 - a. Material: Metal **[or plastic]** box with removable cover.
 - b. Rating: NEMA 250, **[Type 1][Type 4][or] Type 4X <Insert type>** for indoor applications and **[Type 1][Type 4][or] Type 4X <Insert type>** for outdoor applications.
 - c. Field Wiring Connection: Terminal block.
 - d. Conduit Connection: **1/2-inch (16-mm)[or 3/4-inch (20-mm)]** trade size.
 11. Gasket: For attachment to duct or equipment to seal penetration airtight.
 12. Mounting Clips: **[Copper][Plastic][Material to match probe]<Insert material>**; specifically designed for flexible probes to achieve radius ends when installed in serpentine arrangements.
- C. Platinum RTD Outdoor Air Temperature Sensors:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Minco]
 - j. [Schneider Electric USA, Inc.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Minco]
 - j. [Schneider Electric USA, Inc.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. <Insert manufacturer's name>
3. Source Limitations: Obtain all platinum RTD outdoor air temperature sensors from a single manufacturer.
4. Factory Calibration: Factory calibrate each instrument to [NIST-]traceable standards and include instrument with a calibration certificate.
5. Two- or three-wire, PTFE-insulated, minimum 22-gauge stranded copper leads.
6. Performance:
 - a. Repeatability: Within [0.5 deg F (0.3 deg C)]<Insert temperature>.
 - b. Self-Heating: Negligible.
 - c. Resistance: [100 ohms][or][1000 ohms][100 or 1000 ohms as indicated for each application under Part 3 or on the Drawings] ohms.
 - d. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/deg C.
 - e. Temperature Range: As required by application, not less than [Minus 30 to 120 deg F (Minus 34 to 49 deg C)][Minus 40 to 158 deg F (Minus 45 to 70 deg C)][Minus 50 to 275 deg F (Minus 45 to 135 deg C)]<Insert temperature range>.
 - f. Accuracy: At 32 deg F (0 deg C) within [0.54 deg F (0.3 deg C)]<Insert temperature>.
7. Output Signal: Resistance in ohms.
8. Sensor Assembly:
 - a. Probe: Single-point RTD wired within a stainless steel[or plastic] sheath.
 - b. Solar Shield: Stainless steel[or plastic].
9. Enclosure:

- a. Material: Metal[**or plastic**] box or combination conduit and outlet box; removable cover and gasket.
- b. Rating: NEMA 250, [Type 3R][Type 4][or][Type 4X]<Insert type>.
- c. Field Wiring Connection: Terminal block.
- d. Conduit Connection: 1/2-inch (16-mm)[**or 3/4-inch (20-mm)**] trade size.

D. Platinum RTD Space Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Minco]
 - j. [Schneider Electric USA, Inc.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. [Vaisala]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Minco]
 - j. [Schneider Electric USA, Inc.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. [Vaisala]
 - m. <Insert manufacturer's name>
3. Source Limitations: Obtain all platinum RTD space air temperature sensors from a single manufacturer.
4. Factory Calibration: Factory calibrate each instrument to [NIST-]traceable standards and include instrument with a calibration certificate.
5. Two- or three-wire, PTFE-insulated, minimum 22-gauge stranded copper leads.
6. Performance:
 - a. Repeatability: Within [0.5 deg F (0.3 deg C)]<Insert temperature>.
 - b. Self-Heating: Negligible.
 - c. Resistance: [100 ohms][or][1000 ohms][100 or 1000 ohms as indicated for each

- application under Part 3 or on the Drawings].**
- d. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/deg C.
 - e. Temperature Range: As required by application, not less than [Minus 40 to 185 deg F (Minus 40 to 85 deg C)][35 to 122 deg F (2 to 50 deg C)]<Insert temperature range>.
 - f. Accuracy: At 32 deg F (0 deg C) within [0.27 deg F (0.15 deg C)][0.54 deg F (0.3 deg C)][0.27 deg F (0.15 deg C) or 0.54 deg F (0.3 deg C) as required by application]<Insert temperature>.
7. Output Signal: Resistance in ohms.
 8. Sensor Assembly:
 - a. Mount temperature sensing element under a bright-white, non-yellowing, plastic enclosure.
 - b. Enclosure Rating: NEMA 250, Type 1.
 - c. Mounting: Provide mounting compatible with surface mounted to and electrical box used.
 - d. Wiring Connection: Concealed wiring connection.
 - 1) Terminal block.
 - 2) Multi-conductor modular connector.
- E. Platinum RTD Space Air Temperature Sensors-Flush-Mount, Flat-Face Cover:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Greystone Energy Systems, Inc.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Johnson Controls, Inc.]**
 - g. **[MAMAC Systems, Inc.]**
 - h. **[Minco]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Greystone Energy Systems, Inc.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Johnson Controls, Inc.]**
 - g. **[MAMAC Systems, Inc.]**
 - h. **[Minco]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain all platinum RTD space air temperature sensors with flush-mount, flat-face cover from a single manufacturer.

4. Factory Calibration: Factory calibrate each instrument to **[NIST]**traceable standards and include instrument with a calibration certificate.
5. Two- or three-wire, PTFE-insulated, minimum 22-gauge stranded copper leads.
6. Description: Sensor with flush-mounted, flat-face brushed-metal cover, intended to provide a finished appearance in areas where aesthetics is a high priority.
7. Performance:
 - a. Repeatability: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>**.
 - b. Self-Heating: Negligible.
 - c. Resistance: **[100 ohms][or][1000 ohms][100 or 1000 ohms as indicated for each application under Part 3 or on the Drawings]**.
 - d. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/deg C.
 - e. Temperature Range: As required by application, not less than **[Minus 40 to 160 deg F (Minus 40 to 71 deg C)][Minus 4 to 140 deg F (Minus 20 to 60 deg C)][32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.
 - f. Accuracy: At 32 deg F (0 deg C) within **[0.27 deg F (0.15 deg C)][0.54 deg F (0.3 deg C)][0.27 deg F (0.15 deg C) or 0.54 deg F (0.3 deg C) as required by application]<Insert temperature>**.
8. Output Signal: Resistance in ohms.
9. Sensor Assembly:
 - a. Mount temperature-sensing element under a flush, brushed stainless steel **[or aluminum]** flat cover plate.
 - b. Enclosure Rating: NEMA 250, Type 1.
 - c. Mounting: Provide mounting compatible with surface mounted to and electrical box used.
 - d. Wiring Connection: Concealed wiring connection.

F. Platinum RTD Space Air Temperature Sensors, Button Style:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Siemens Industry, Inc., Building Technologies Division]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Siemens Industry, Inc., Building Technologies Division]**
 - g. **<Insert manufacturer's name>**

3. Source Limitations: Obtain all platinum RTD space air temperature sensors with button-style from a single manufacturer.
 4. Factory Calibration: Factory calibrate each instrument to **[NIST-]**traceable standards and include instrument with a calibration certificate.
 5. Description: Flush-mount, button style, sensor intended to provide a discreet, nonobtrusive, and highly finished appearance in areas where aesthetics is a high priority.
 6. Performance:
 - a. Repeatability: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>**.
 - b. Self-Heating: Negligible.
 - c. Resistance: **[100 ohms][or][1000 ohms][100 or 1000 ohms as indicated for each application under Part 3 or on the Drawings]**.
 - d. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/deg C.
 - e. Temperature Range: As required by application, not less than **[Minus 40 to 140 deg F (Minus 40 to 60 deg C)][Minus 40 to 185 deg F (Minus 45 to 85 deg C)][32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.
 - f. Accuracy: At 32 deg F (0 deg C) within **[0.27 deg F (0.15 deg C)][0.54 deg F (0.3 deg C)][0.27 deg F (0.15 deg C) or 0.54 deg F (0.3 deg C) as required by application]<Insert temperature>**.
 7. Output Signal: Resistance in ohms.
 8. Sensor Assembly:
 - a. Conceal temperature-sensing element under a **[brushed-brass][brushed stainless steel][paintable plastic][black plastic][bright-white plastic]** flush-mount, button-style cover.
 - 1) Metal sensor assemblies with threaded shaft and backnut to secure sensor to mounting substrate.
 - 2) Plastic sensor assemblies with ribbed shafts to secure sensor to mounting substrate.
 - b. Enclosure Rating: NEMA 250, Type 1.
 - c. Two-**[or three-]** wire, PTFE-insulated, minimum 22-gauge stranded copper leads. Each application determines length of leads.
 9. Mounting Kit: Include a mounting kit with each sensor.
- G. Platinum RTD Space Air Temperature Sensors with Occupant Interface Features:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Greystone Energy Systems, Inc.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Johnson Controls, Inc.]**
 - g. **[MAMAC Systems, Inc.]**
 - h. **[Schneider Electric USA, Inc.]**
 - i. **[Siemens Industry, Inc., Building Technologies Division]**
 - j. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Greystone Energy Systems, Inc.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Johnson Controls, Inc.]**
 - g. **[MAMAC Systems, Inc.]**
 - h. **[Schneider Electric USA, Inc.]**
 - i. **[Siemens Industry, Inc., Building Technologies Division]**
 - j. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all platinum RTD space air temperature sensors with occupant interface features from a single manufacturer.
 4. Factory Calibration: Factory calibrate each instrument to **[NIST-]**traceable standards and include instrument with a calibration certificate.
 5. Description: Sensor with integral occupant interface features
 6. Performance:
 - a. Repeatability: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>**.
 - b. Self-Heating: Negligible.
 - c. Resistance: **[100 ohms][or][1000 ohms][100 or 1000 ohms as indicated for each application under Part 3 or on the Drawings]**.
 - d. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/deg C.
 - e. Temperature Range: As required by application, not less than **[Minus 40 to 185 deg F (Minus 40 to 85 deg C)][35 to 122 deg F (2 to 50 deg C)]<Insert temperature range>**.
 - f. Accuracy: At 32 deg F (0 deg C) within **[0.27 deg F (0.15 deg C)][0.54 deg F (0.3 deg C)][0.27 deg F (0.15 deg C) or 0.54 deg F (0.3 deg C) as required by application]<Insert temperature>**.
 7. Output Signal: Resistance in ohms.
 8. Sensor Assembly:
 - a. Mount temperature-sensing element under a bright-white, non-yellowing, plastic cover.
 - b. Enclosure Rating: NEMA 250, Type 1.
 - c. Mounting: Provide mounting compatible with surface shape mounted to and electrical box used.
 - d. Wiring Connection: Concealed wiring connection.
 - 1) Terminal block.
 - 2) Multi-conductor modular connector.
 9. Occupant Interface Features: Where indicated, include instrument with the following features:
 - a. Display: Backlit LCD display of temperature in **[degrees F][degrees C][degrees that is switchable between either degree C or degree F]**.
 - b. Operation Override: Local adjustment on face of enclosure for occupant to initiate HVAC zone "On" operation.
 - c. Temperature Set Point: Local adjustment on face of enclosure for occupant to adjust zone temperature set point.
 - d. Fan Speed: Multispeed adjustment.
 - e. Occupancy Detector: Sensor with integral PIR-type occupancy detector.
 - f. **<Insert feature>**.

H. Thermistor Single-Point Duct Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Minco]
 - j. [Schneider Electric USA, Inc.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Minco]
 - j. [Schneider Electric USA, Inc.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. <Insert manufacturer's name>
3. Source Limitations: Obtain all thermistor single-point duct air temperature sensors from a single manufacturer.
4. Performance:
 - a. Temperature Drift: Within [0.5 deg F (0.3 deg C)]<Insert temperature> over [10]<Insert value> years.
 - b. Temperature Range: [Minus 50 to 275 deg F (Minus 46 to 135 deg C)]<Insert temperature range>.
 - c. Interchangeable Accuracy: At 77 deg F (25 deg C) within [0.18 deg F (0.1 deg C)][0.36 deg F (0.2 deg C)][0.5 deg F (0.3 deg C)]<Insert temperature>.
 - d. Repeatability: Within [0.5 deg F (0.3 deg C)]<Insert temperature>.
 - e. Self-Heating: Negligible.
 - f. Two-wire, PTFE-insulated, 22-gauge stranded copper leads.
5. Output Signal: Resistance in ohms.
6. Thermistor: 10000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C, Type II, negative-temperature coefficient (NTC).
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit

encased in epoxy.

7. Sensor Assembly:
 - a. Probe: Single-point thermistor in a stainless steel sheath.
 - b. Probe Length: As required by application to achieve tip at midpoint of air tunnel, up to **18 inches (450 mm)** long.
8. Enclosure:
 - a. Material: Metal[**or plastic**] junction box with removable cover.
 - b. Rating: NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
9. Gasket: For attachment to duct or equipment to seal penetration airtight.
10. Conduit Connection: **1/2-inch (16-mm)** [**or 3/4-inch (20-mm)**] trade size.

I. Thermistor Averaging Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all thermistor averaging air temperature sensors from a single manufacturer.
4. Description: Multiple internal thermistors located across length of sensor probe and internally wired to signal a single average temperature reading.

5. Performance:
 - a. Temperature Drift: Within [0.5 deg F (0.3 deg C)]<Insert temperature> over [10]<Insert value> years.
 - b. Temperature Range: As required by application, not less than [Minus 50 to 275 deg F (Minus 45 to 135 deg C)]<Insert temperature range>.
 - c. Interchangeable Accuracy: At 77 deg F (25 deg C) within [0.18 deg F (0.1 deg C)][0.36 deg F (0.2 deg C)][0.5 deg F (0.3 deg C)]<Insert temperature>.
 - d. Repeatability: Within [0.5 deg F (0.3 deg C)]<Insert temperature>.
 - e. Self-Heating: Negligible.
 6. Output Signal: Resistance in ohms.
 7. Thermistor: 10000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C, Type II, negative temperature coefficient (NTC).
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
 8. Sensor Probe:
 - a. Type: Flexible probes; option to use rigid probes for air tunnels up to [20 inches (500 mm)][36 inches (900 mm)]<Insert distance>.
 - b. Material:
 - 1) Flexible: [Aluminum][Brass][Copper][or][stainless steel]<Insert material>.
 - 2) Rigid: Flexible: [Stainless steel]<Insert material>.
 - c. Flexible probes formable to a minimum [4-inch (100-mm)]<Insert distance> radius.
 - d. Length: As required by application to account for temperature variations across entire cross section of air tunnel.
 9. Enclosure:
 - a. Material: Metal[or plastic] box with removable cover.
 - b. Rating: NEMA 250, [Type 1][Type 4][or][Type 4X]<Insert type> for indoor applications and [Type 4][or][Type 4X]<Insert type> for outdoor applications.
 - c. Conduit Connection: 1/2-inch (16-mm)[or 3/4-inch (20-mm)] trade size.
 10. Gasket: For attachment to duct or equipment to seal penetration airtight.
 11. Mounting Clips: [Copper][Plastic][Material to match probe]<Insert material>; specifically designed for flexible probes to achieve radius ends when installed in serpentine arrangements.
- J. Thermistor Outdoor Air Temperature Sensors:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]

- h. **[MAMAC Systems, Inc.]**
 - i. **[Minco]**
 - j. **[Schneider Electric USA, Inc.]**
 - k. **[Siemens Industry, Inc., Building Technologies Division]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**
 - i. **[Minco]**
 - j. **[Schneider Electric USA, Inc.]**
 - k. **[Siemens Industry, Inc., Building Technologies Division]**
 - l. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all thermistor outdoor air temperature sensors from a single manufacturer.
4. Performance:
- a. Temperature Drift: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>** over **[10]<Insert value>** years.
 - b. Temperature Range: As required by application, not less than **[Minus 50 to 275 deg F (Minus 45 to 135 deg C)]<Insert temperature range>**.
 - c. Interchangeable Accuracy: At 77 deg F (25 deg C) within **[0.18 deg F (0.1 deg C)][0.36 deg F (0.2 deg C)][0.5 deg F (0.3 deg C)]<Insert temperature>**.
 - d. Repeatability: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>**.
 - e. Self-Heating: Negligible.
5. Output Signal: Resistance in ohms.
6. Thermistor: 10000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C, Type II, negative temperature coefficient (NTC).
- a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
7. Sensor Assembly:
- a. Probe: Single-point thermistor wired within a stainless steel[**or plastic**] sheath.
 - b. Solar Shield: Stainless steel[**or plastic**].
8. Enclosure:
- a. Material: Metal[**or plastic**] box or combination conduit and outlet box; removable cover and gasket.
 - b. Rating: NEMA 250, **[Type 4][or][Type 4X]<Insert type>**.
9. Conduit Connection: **1/2-inch (16-mm)[or 3/4-inch (20-mm)]** trade size.

K. Thermistor Space Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Dwyer Instruments, Inc]**
 - d. **[Greystone Energy Systems, Inc.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Johnson Controls, Inc.]**
 - g. **[MAMAC Systems, Inc.]**
 - h. **[Minco]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Dwyer Instruments, Inc]**
 - d. **[Greystone Energy Systems, Inc.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Johnson Controls, Inc.]**
 - g. **[MAMAC Systems, Inc.]**
 - h. **[Minco]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all thermistor space air temperature sensors from a single manufacturer.
4. Performance:
 - a. Temperature Drift: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>** over **[10]<Insert value>** years.
 - b. Temperature Range: As required by application, not less than **[Minus 40 to 185 deg F (Minus 40 to 85 deg C)][32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.
 - c. Interchangeable Accuracy: At 77 deg F (25 deg C) within **[0.18 deg F (0.1 deg C)][0.36 deg F (0.2 deg C)][0.5 deg F (0.3 deg C)]<Insert temperature>**.
 - d. Repeatability: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>**.
 - e. Self-Heating: Negligible.
5. Output Signal: Resistance in ohms.
6. Thermistor: 10000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C, Type II, negative temperature coefficient (NTC).
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
7. Sensor Assembly:

- a. Mount temperature-sensing element under a bright-white, non-yellowing, plastic enclosure.
- b. Enclosure Rating: NEMA 250, Type 1.
- c. Mounting: Provide mounting compatible with surface mounted to and electrical box used.
- d. Wiring Connection: Concealed wiring connection.
 - 1) Terminal block.
 - 2) Multiconductor modular connector.

L. Thermistor Space Air Temperature Sensors - Flush-Mount, Flat-Face Cover:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[MAMAC Systems, Inc.]**
 - g. **[Minco]**
 - h. **[Schneider Electric USA, Inc.]**
 - i. **[Siemens Industry, Inc., Building Technologies Division]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[MAMAC Systems, Inc.]**
 - g. **[Minco]**
 - h. **[Schneider Electric USA, Inc.]**
 - i. **[Siemens Industry, Inc., Building Technologies Division]**
 - j. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all thermistor space air temperature sensors with flush-mount, flat-face cover from a single manufacturer.
4. Description: Sensor with flush-mounted, flat-face brushed-metal cover, intended to provide a finished appearance in areas where aesthetics is a high priority.
5. Performance:
 - a. Temperature Drift: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>** over **[10]<Insert value>** years.
 - b. Temperature Range: As required by application, not less than **[Minus 40 to 185 deg F (Minus 40 to 85 deg C)][32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.
 - c. Interchangeable Accuracy: At 77 deg F (25 deg C) within **[0.18 deg F (0.1 deg C)][0.36 deg F (0.2 deg C)][0.5 deg F (0.3 deg C)]<Insert temperature>**.
 - d. Repeatability: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>**.
 - e. Self-Heating: Negligible.

6. Output Signal: Resistance in ohms.
 7. Thermistor: 10000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C, Type II, negative temperature coefficient (NTC).
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
 8. Sensor Assembly:
 - a. Mount temperature-sensing element under a flush, **[brushed-aluminum][or][brushed stainless steel]** flat cover plate.
 - b. Enclosure Rating: NEMA 250, Type 1.
 - c. Mounting: Provide mounting compatible with surface mounted to and electrical box used.
 - d. Wiring Connection: Concealed wiring connection.
- M. Thermistor Space Air Temperature Sensors - Button Style:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Schneider Electric USA, Inc.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Schneider Electric USA, Inc.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain all thermistor space air temperature sensors with button style from a single manufacturer.
 4. Description: Flush-mounted, button-style sensor intended to provide a discreet, nonobtrusive, and highly finished appearance in areas where aesthetics is a high priority.
 5. Performance:
 - a. Temperature Drift: Within **[0.5 deg F (0.3 deg C)]<Insert temperature>** over **[10]<Insert value>** years.
 - b. Temperature Range: As required by application, not less than **[Minus 40 to 185 deg F (Minus 40 to 85 deg C)][32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.
 - c. Interchangeable Accuracy: At 77 deg F (25 deg C) within **[0.18 deg F (0.1 deg C)][0.36 deg F (0.2 deg C)][0.5 deg F (0.3 deg C)]<Insert temperature>**.

- d. Repeatability: Within [0.5 deg F (0.3 deg C)]<Insert temperature>.
 - e. Self-Heating: Negligible.
6. Output Signal: Resistance in ohms.
7. Thermistor: 10000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C, Type II, negative temperature coefficient (NTC).
- a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
8. Sensor Assembly:
- a. Conceal temperature sensing element under a [brushed-brass][brushed stainless steel][paintable plastic][black plastic][bright-white plastic] flush-mount, button-style cover.
 - 1) Metal sensor assemblies with threaded shaft and backnut to secure sensor to mounting substrate.
 - 2) Plastic sensor assemblies with ribbed shafts to secure sensor to mounting substrate.
 - b. Enclosure Rating: NEMA 250, Type 1.
 - c. Wiring Connection: Two-wire, PTFE-insulated, minimum 22-gauge stranded copper leads. Length of leads as required by application.
9. Mounting Kit: Include a mounting kit with each sensor.
- N. Thermistor Space Air Temperature Sensors with Occupant Interface Features:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Schneider Electric USA, Inc.]
 - j. [Siemens Industry, Inc., Building Technologies Division]
 - k. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]

- g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Schneider Electric USA, Inc.]
 - j. [Siemens Industry, Inc., Building Technologies Division]
 - k. <Insert manufacturer's name>
3. Source Limitations: Obtain all thermistor space air temperature sensors with occupant override features from a single manufacturer.
 4. Description: Sensor with integral occupant interface features.
 5. Performance:
 - a. Temperature Drift: Within [0.5 deg F (0.3 deg C)]<Insert temperature> over [10]<Insert value> years.
 - b. Temperature Range: As required by application, not less than [Minus 40 to 185 deg F (Minus 40 to 85 deg C)][32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>.
 - c. Interchangeable Accuracy: At 77 deg F (25 deg C) within [0.18 deg F (0.1 deg C)][0.36 deg F (0.2 deg C)][0.5 deg F (0.3 deg C)]<Insert temperature>.
 - d. Repeatability: Within [0.5 deg F (0.3 deg C)]<Insert temperature>.
 - e. Self-Heating: Negligible.
 6. Output Signal: Resistance in ohms.
 7. Thermistor: 10000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C, Type II, negative temperature coefficient (NTC).
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
 8. Sensor Assembly:
 - a. Mount temperature sensing element under a bright-white, non-yellowing, plastic cover.
 - b. Enclosure Rating: NEMA 250, Type 1.
 - c. Mounting: Provide mounting compatible with surface shape mounted to and electrical box used.
 - d. Wiring Connection: Concealed wiring connection.
 - 1) Terminal block.
 - 2) Multiconductor modular connector.
 9. Occupant Interface Features: Where indicated, include instrument with the following features:
 - a. Display: Backlit LCD display of temperature in [degrees F][degrees C][degrees that is switchable between either degree C or degree F].
 - b. Occupancy Override: Local adjustment on face of enclosure for occupant to initiate zone HVAC operation.
 - c. Temperature Set Point: Local adjustment on face of enclosure for occupant to adjust zone temperature set point.
 - d. Fan Speed: Multispeed adjustment.
 - e. Occupancy Detector: Sensor with integral PIR-type occupancy detector.
 - f. <Insert feature>.

2.3 AIR TEMPERATURE SENSORS WITH NETWORK COMMUNICATION SIGNAL

A. Air Temperature Sensors with Network Communication Signal for Space Applications:

1. Manufacturers: Subject to compliance with requirements, [provide products by the

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Greystone Energy Systems, Inc.]
 - e. [Honeywell International Inc.]
 - f. [Johnson Controls, Inc.]
 - g. [Schneider Electric USA, Inc.]
 - h. [Siemens Industry, Inc., Building Technologies Division]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Greystone Energy Systems, Inc.]
 - e. [Honeywell International Inc.]
 - f. [Johnson Controls, Inc.]
 - g. [Schneider Electric USA, Inc.]
 - h. [Siemens Industry, Inc., Building Technologies Division]
 - i. <Insert manufacturer's name>
3. Source Limitations: Obtain all air temperature sensors with network communication signal for space applications from a single manufacturer.
4. Description: Air temperature sensors with network communication signal for wired connection to DDC network.
5. Certifications: [BACnet Testing Lab (BTL) certification]<Insert certification>.
6. Factory Calibration: Factory calibrate each instrument to [NIST-]traceable standards and include instrument with a calibration certificate.
7. Performance:
- a. Temperature:
 - 1) Accuracy: [0.5 deg F (0.3 deg C)][1.0 deg F (0.6 deg C)]<Insert temperature>.
 - 2) Measured Range: [55 to 85 deg F (13 to 29 deg C)][32 to 104 deg F (0 to 40 deg C)]<Insert temperature range>.
 - 3) Ambient Operating Range: [32 to 104 deg F (0 to 40 deg C)]<Insert temperature range>.
8. Network Communication Interface: [BACnet IP][BACnet MS/TP][or][Modbus RTU]<Insert network protocol>.
9. Temperature Sensor Type: [100-ohm platinum RTD][1000-ohm platinum RTD][or][10000-ohm, Type II negative temperature coefficient (NTC) thermistor][Manufacturer's choice of sensor type to achieve performance indicated, long-term stability, and reliability].
10. Enclosure:
- a. Material: Plastic; bright white, non-yellowing.
 - b. Rating: NEMA 250, Type 1.

11. Additional Features: Where indicated, include instrument with the following features:
 - a. Display: Backlit LCD display of temperature in **[degrees F][degrees C][degrees that is switchable between either degree C or degree F]**.
 - b. Occupancy Override: Local adjustment on face of enclosure for occupant to initiate zone HVAC operation.
 - c. Temperature Set Point: Local adjustment on face of enclosure for occupant to adjust zone temperature set point.
 - d. Fan Speed: Multispeed adjustment.
 - e. Occupancy Detector: Sensor with integral PIR-type occupancy detector.
 - f. **<Insert feature>**.
12. Mounting: Concealed screw mount; compatible with mounting surface.

2.4 MULTIVARIABLE AIR TEMPERATURE SENSORS AND TRANSMITTERS

A. Combination Carbon-Dioxide and Air Temperature Sensors and Transmitters for Duct Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Honeywell International Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Schneider Electric USA, Inc.]**
 - f. **[Siemens Industry, Inc., Building Technologies Division]**
 - g. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Honeywell International Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Schneider Electric USA, Inc.]**
 - f. **[Siemens Industry, Inc., Building Technologies Division]**
 - g. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all combination carbon-dioxide and air temperature sensors and transmitters for duct applications from a single manufacturer.
4. Certifications: **[BACnet Testing Lab (BTL) certification]<Insert certification>**.
5. Description:
 - a. Carbon-dioxide and air temperature sensors and transmitters combined into a single instrument for wired connection to DDC controllers.
 - b. Intended for use in duct applications.
6. Factory Calibration: Factory calibrate each instrument and include instrument with a calibration

- certificate.
7. Performance:
 - a. Carbon Dioxide:
 - 1) Carbon-Dioxide Concentration Range: Zero to [2000]<Insert value> ppm.
 - 2) Accuracy: Within [2][3][4]<Insert value> percent of reading, plus or minus [30][40][50]<Insert value> ppm.
 - 3) Repeatability: Within [1]<Insert value> percent of full scale.
 - 4) Long-Term Stability: Within [5]<Insert value> percent of full scale after more than [5]<Insert value> years.
 - 5) Response Time: Within [60]<Insert value> seconds.
 - 6) Warm-up Time: Within [5]<Insert value> minutes.
 - b. Temperature:
 - 1) Accuracy: [0.54 deg F (0.3 deg C)][1.0 deg F (0.6 deg C)]<Insert temperature>.
 - 2) Measured Range: [32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>.
 - 3) Ambient Operating Range: [32 to 104 deg F (0 to 40 deg C)]<Insert temperature range>.
 8. Analog Output Signal:
 - a. Carbon Dioxide: [4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements> output signal, linearized to carbon-dioxide concentration in parts per million (ppm).
 - b. Temperature: [Temperature sensor resistance (ohms)][4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>.
 9. Network Communication Interface: [BACnet MS/TP][or][Modbus RTU]<Insert network protocol>.
 10. Carbon-Dioxide Sensor Type: Nondispersive infrared or equivalent technology providing performance indicated, long-term stability, and reliability.
 11. Temperature Sensor Type: [100-ohm platinum RTD][1000-ohm platinum RTD][or][10000-ohm, Type II negative temperature coefficient (NTC) thermistor][Manufacturer's choice of sensor type to achieve performance indicated, long-term stability, and reliability].
 12. Enclosure: Plastic; NEMA 250, [Type 1][Type 4][or][Type 4X]<Insert type>.
 13. Display: Backlit LCD display of carbon dioxide concentration in parts per million (ppm), relative humidity in percent relative humidity, and temperature in [degrees F][degrees C].
 14. Mounting: Screw mount; compatible with mounting surface.
- B. Combination Carbon-Dioxide and Air Temperature Sensors and Transmitters for Space Applications:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Honeywell International Inc.]
 - f. [Johnson Controls, Inc.]
 - g. [Schneider Electric USA, Inc.]
 - h. [Siemens Industry, Inc., Building Technologies Division]

- i. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - j. **[Vaisala]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Honeywell International Inc.]**
 - f. **[Johnson Controls, Inc.]**
 - g. **[Schneider Electric USA, Inc.]**
 - h. **[Siemens Industry, Inc., Building Technologies Division]**
 - i. **[Telaire; a brand of Amphenol Thermometrics Inc.]**
 - j. **[Vaisala]**
 - k. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all combination carbon-dioxide and air temperature sensors and transmitters for space applications from a single manufacturer.
4. Certifications: **[BACnet Testing Lab (BTL) certification]<Insert certification>**.
5. Description:
 - a. Carbon-dioxide and air temperature sensors and transmitters combined into a single instrument for wired connection to DDC controllers.
 - b. Intended for use in applications controlling indoor, conditioned space.
6. Factory Calibration: Factory calibrate each instrument to **[NIST-]traceable** standards and include instrument with a calibration certificate.
7. Performance:
 - a. Carbon Dioxide:
 - 1) Carbon-Dioxide Concentration Range: Zero to **[2000]<Insert value>** ppm.
 - 2) Accuracy: Within **[2][3][4]<Insert value>** percent of reading, plus or minus **[30][40][50]<Insert value>** ppm.
 - 3) Repeatability: Within **[1]<Insert value>** percent of full scale.
 - 4) Long-Term Stability: Within **[5]<Insert value>** percent of full scale after more than **[5]<Insert value>** years.
 - 5) Response Time: Within **[60]<Insert value>** seconds.
 - 6) Warm-up Time: Within **[5]<Insert value>** minutes.
 - b. Temperature:
 - 1) Accuracy: **[0.5 deg F (0.3 deg C)][1.0 deg F (0.6 deg C)]<Insert temperature>**.
 - 2) Measured Range: **[55 to 85 deg F (13 to 29 deg C)][32 to 104 deg F (0 to 40 deg C)]<Insert temperature range>**.
 - 3) Ambient Operating Range: **[32 to 104 deg F (0 to 40 deg C)]<Insert temperature range>**.
8. Analog Output Signal:
 - a. Carbon Dioxide: **[4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>** output signal, linearized to carbon-dioxide concentration in parts per million (ppm).

- b. Temperature: **[Temperature sensor resistance (ohms)][4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>.**
 9. Network Communication Interface: **[BACnet MS/TP][or][Modbus RTU]<Insert network protocol>.**
 10. Carbon-Dioxide Sensor Type: Nondispersive infrared or equivalent technology providing performance indicated, long-term stability, and reliability.
 11. Temperature Sensor Type: **[100-ohm platinum RTD][1000-ohm platinum RTD][or][10000-ohm, Type II negative temperature coefficient (NTC) thermistor][Manufacturer's choice of sensor type to achieve performance indicated, long-term stability, and reliability].**
 12. Enclosure:
 - a. Material: Plastic; bright white, non-yellowing.
 - b. Rating: NEMA 250, Type 1.
 13. Additional Features: Where indicated, include instrument with the following features:
 - a. Display: Backlit LCD display of carbon-dioxide concentration in parts per million (ppm), relative humidity in percent relative humidity, and temperature in **[degrees F][degrees C][degrees that is switchable between either degree C or degree F].**
 - b. Occupancy Override: Local adjustment on face of enclosure for occupant to initiate zone HVAC operation.
 - c. Temperature Set Point: Local adjustment on face of enclosure for occupant to adjust zone temperature set point.
 - d. Fan Speed: Multispeed adjustment.
 - e. Occupancy Detector: Sensor with integral PIR-type occupancy detector.
 - f. **<Insert feature>.**
 14. Mounting: Concealed screw mount; compatible with mounting surface.
- C. Combination Carbon-Dioxide, Relative Humidity, and Air Temperature Sensors and Transmitters for Duct Applications:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Honeywell International Inc.]**
 - d. **[Schneider Electric USA, Inc.]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Dwyer Instruments, Inc]**
 - c. **[Honeywell International Inc.]**
 - d. **[Schneider Electric USA, Inc.]**
 - e. **[Siemens Industry, Inc., Building Technologies Division]**
 - f. **<Insert manufacturer's name>**

3. Source Limitations: Obtain all combination carbon-dioxide, relative humidity, and air temperature sensors and transmitters for duct applications from a single manufacturer.
4. Certifications: **[BACnet Testing Lab (BTL) certification]<Insert certification>**.
5. Description:
 - a. Carbon-dioxide, relative humidity, and air temperature sensors and transmitters combined into a single instrument for wired connection to DDC controllers.
 - b. Intended for use in duct applications.
6. Factory Calibration: Factory calibrate each instrument and include instrument with a calibration certificate.
7. Performance:
 - a. Carbon Dioxide:
 - 1) Carbon-Dioxide Concentration Range: Zero to **[2000]<Insert value>** ppm.
 - 2) Accuracy: Within **[2][3][4]<Insert value>** percent of reading, plus or minus **[30][40][50]<Insert value>** ppm.
 - 3) Repeatability: Within **[1]<Insert value>** percent of full scale.
 - 4) Long-Term Stability: Within **[5]<Insert value>** percent of full scale after more than **[5]<Insert value>** years.
 - 5) Response Time: Within **[60]<Insert value>** seconds.
 - 6) Warm-up Time: Within **[5]<Insert value>** minutes.
 - b. Relative Humidity:
 - 1) Accuracy: **[2][3][4]<Insert value>** percent relative humidity.
 - 2) Calibrated Range: **[5 to 65][20 to 80][10 to 90][0 to 100]<Insert value>** percent relative humidity.
 - 3) Operating Stability: **[Within 0.5 percent/year]<Insert requirement>**.
 - 4) Response Time: Within **[10][20]<Insert value>** seconds.
 - c. Temperature:
 - 1) Accuracy: **[0.54 deg F (0.3 deg C)][1.0 deg F (0.6 deg C)]<Insert temperature>**.
 - 2) Measured Range: **[32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.
 - 3) Ambient Operating Range: **[32 to 104 deg F (0 to 40 deg C)]<Insert temperature range>**.
8. Analog Output Signal:
 - a. Carbon Dioxide: **[4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>** output signal, linearized to carbon-dioxide concentration in parts per million (ppm).
 - b. Relative Humidity: **[4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>**.
 - c. Temperature: **[Temperature sensor resistance (ohms)][4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>**.
9. Network Communication Interface: **[BACnet MS/TP][or][Modbus RTU]<Insert network protocol>**.
10. Carbon-Dioxide Sensor Type: Nondispersive infrared or equivalent technology providing performance indicated, long-term stability, and reliability.
11. Relative Humidity Sensor Type: Manufacturer's choice of sensor type to achieve performance indicated, long-term stability, and reliability.
12. Temperature Sensor Type: **[100-ohm platinum RTD][1000-ohm platinum RTD][or][10000-ohm, Type II negative temperature coefficient (NTC) thermistor][Manufacturer's choice of sensor type to achieve performance indicated, long-term stability, and reliability]**.

13. Enclosure: Plastic; NEMA 250, **[Type 1][or][Type 4]<Insert type>**.
14. Display: Backlit LCD display of carbon-dioxide concentration in parts per million (ppm), relative humidity in percent relative humidity, and temperature in **[degrees F][degrees C]**.
15. Mounting: Screw mount; compatible with mounting surface.

D. Combination Carbon-Dioxide, Relative Humidity, and Temperature Sensors and Transmitters for Space Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[Schneider Electric USA, Inc.]**
 - i. **[Siemens Industry, Inc., Building Technologies Division]**
 - j. **[Vaisala]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[Schneider Electric USA, Inc.]**
 - i. **[Siemens Industry, Inc., Building Technologies Division]**
 - j. **[Vaisala]**
 - k. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all combination carbon-dioxide, relative humidity, and air temperature sensors and transmitters for space applications from a single manufacturer.
4. Certifications: **[BACnet Testing Lab (BTL) certification]<Insert certification>**.
5. Description:
 - a. Carbon-dioxide, relative humidity, and air temperature sensors and transmitters combined into a single instrument for wired connection to DDC controllers.
 - b. Intended for use in applications controlling indoor, conditioned space.
6. Factory Calibration: Factory calibrate each instrument to **[NIST-]**traceable standards and include instrument with a calibration certificate.
7. Performance:
 - a. Carbon Dioxide:

- 1) Carbon-Dioxide Concentration Range: Zero to [2000]<Insert value> ppm.
 - 2) Accuracy: Within [2][3][4]<Insert value> percent of reading, plus or minus [30][40][50]<Insert value> ppm.
 - 3) Repeatability: Within [1]<Insert value> percent of full scale.
 - 4) Long-Term Stability: Within [5]<Insert value> percent of full scale after more than [5]<Insert value> years.
 - 5) Response Time: Within [60]<Insert value> seconds.
 - 6) Warm-up Time: Within [5]<Insert value> minutes.
- b. Relative Humidity:
- 1) Accuracy: [2][3][5]<Insert value>percent relative humidity.
 - 2) Calibrated Range: [5 to 65][20 to 80][10 to 90][0 to 100]<Insert value> percent relative humidity.
 - 3) Operating Stability: [Within 0.5 percent/year]<Insert requirement>.
 - 4) Response Time: Within [10][20]<Insert value> seconds.
- c. Temperature:
- 1) Accuracy: [0.54 deg F (0.3 deg C)][1.0 deg F (0.6 deg C)]<Insert temperature>.
 - 2) Measured Range: [32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>.
 - 3) Ambient Operating Range: [32 to 104 deg F (0 to 40 deg C)]<Insert temperature range>.
8. Analog Output Signal:
- a. Carbon Dioxide: [4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements> output signal, linearized to carbon-dioxide concentration in parts per million (ppm).
 - b. Relative Humidity: [4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>.
 - c. Temperature: [Temperature sensor resistance (ohms)][4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>.
9. Network Communication Interface: [BACnet MS/TP][or][Modbus RTU]<Insert network protocol>.
10. Carbon-Dioxide Sensor Type: Nondispersive infrared or equivalent technology providing performance indicated, long-term stability, and reliability.
11. Relative Humidity Sensor Type: Manufacturer's choice of sensor type to achieve performance indicated, long-term stability, and reliability.
12. Temperature Sensor Type: [100-ohm platinum RTD][1000-ohm platinum RTD][or][10000-ohm, Type II negative temperature coefficient (NTC) thermistor][Manufacturer's choice of sensor type to achieve performance indicated, long-term stability, and reliability].
13. Enclosure:
- a. Material: Plastic; bright white, non-yellowing.
 - b. Rating: NEMA 250, Type 1.
14. Additional Features: Where indicated, include instrument with the following features:
- a. Display: Backlit LCD display of carbon-dioxide concentration in parts per million (ppm), relative humidity in percent relative humidity, and temperature in [degrees F][degrees C][degrees that is switchable between either degree C or degree F].
 - b. Occupancy Override: Local adjustment on face of enclosure for occupant to initiate zone HVAC operation.
 - c. Temperature Set Point: Local adjustment on face of enclosure for occupant to adjust zone temperature set point.
 - d. Fan Speed: Multispeed adjustment.

- e. Occupancy Detector: Sensor with integral PIR-type occupancy detector.
- f. <Insert feature>.

15. Mounting: Concealed screw mount; compatible with mounting surface.

2.5 WIRELESS AIR TEMPERATURE SENSORS

A. Wireless Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Dwyer Instruments, Inc]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Schneider Electric USA, Inc.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Building Automation Products Inc.; BAPI]**
 - c. **[Dwyer Instruments, Inc]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Schneider Electric USA, Inc.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all wireless air temperature sensors from a single manufacturer.
4. Certifications: **[BACnet Testing Lab (BTL) certification]<Insert certification>**.
5. Description: Wireless temperature sensors communicating with associated receivers, transceivers, or repeaters for wired connection to DDC controllers.
6. Performance:
 - a. Battery Life: **[1][3][5]<Insert value>** years when operating under planned use.
 - b. Temperature:
 - 1) Accuracy: **[0.54 deg F (0.3 deg C)][1.0 deg F (0.6 deg C)]<Insert temperature>**.
 - 2) Measured Range:
 - a) Duct Applications: **[Minus 40 to 185 deg F (Minus 40 to 85 deg C)]<Insert temperature span>**
 - b) Outdoor applications: **[Minus 40 to 185 deg F (Minus 40 to 85 deg C)]<Insert temperature span>**.
 - c) Space Applications: **[32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>**.

- 3) Ambient Operating Range: [32 to 104 deg F (0 to 40 deg C)][45 to 100 deg F (7 to 38 deg C)]<Insert temperature range>.
- c. Radio Frequency (RF) Transmission:
 - 1) Frequency: Nominal [400 MHz][900 MHz][or][2.4 GHz].
 - 2) Interval: Maximum of [90][150]<Insert value> seconds between individual temperature sensor signals sent to DDC controllers.
 - 3) Range: Horizontal line of sight not less than [100 ft. (30 m)][200 ft. (60 m)][300 ft. (90 m)]<Insert distance>.
 - 4) Regulations: Comply with FCC regulations for low-power unlicensed transmitters.
7. Analog Output Signal: [Temperature sensor resistance (ohms)][4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>.
8. Network Communication Interface: [BACnet MS/TP][or][Modbus RTU]<Insert network protocol>.
9. Temperature Sensor Type: [1000-ohm platinum RTD][or][10000-ohm, Type II negative temperature coefficient (NTC) thermistor][Manufacturer's choice of sensor type to achieve performance indicated].
10. Enclosure:
 - a. Material:
 - 1) Duct and Outdoor Applications: Plastic.
 - 2) Space Applications: Plastic; bright white, non-yellowing.
 - b. Rating:
 - 1) Duct: NEMA 250, [Type 4][or][Type 4X]<Insert type>.
 - 2) Outdoor: NEMA 250, Type 4X
 - 3) Space: NEMA 250, Type 1.
11. Additional Features: Where indicated for space applications, include temperature sensor with the following features:
 - a. Battery Level Display: LED to indicated need for replacement.
 - b. Transmission Signal Display: LED to indicate signal trouble.
 - c. Temperature Display: Backlit LCD display of temperature with toggle between Metric (SI) and Imperial (IP) units.
 - d. Occupancy Override: Local adjustment on face of enclosure for occupant to initiate zone HVAC operation.
 - e. Temperature Set Point: Local adjustment on face of enclosure for occupant to adjust zone temperature set point.
 - f. Occupancy Detector: Sensor with integral PIR-type occupancy detector.
 - g. <Insert feature>.
12. Mounting:
 - a. Duct and Outdoor Applications: Screw mount, magnets; compatible with mounting surface.
 - b. Space Applications: [Screw mount][magnets, double-sided foam back tape or Velcro]; compatible with mounting surface.

B. Wireless Air Temperature and Relative Humidity Sensors and Transmitters:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering

products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [ACI Automation; Automation Components Inc]
 - b. [Building Automation Products Inc.; BAPI]
 - c. [Johnson Controls, Inc.]
 - d. [Schneider Electric USA, Inc.]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Building Automation Products Inc.; BAPI]
 - c. [Johnson Controls, Inc.]
 - d. [Schneider Electric USA, Inc.]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain all wireless air temperature and relative humidity sensors and transmitters from a single manufacturer.
4. Certifications: [BACnet Testing Lab (BTL) certification]<Insert certification>.
5. Description:
 - a. Wireless temperature and relative humidity sensors and transmitters communicating with associated receivers, transceivers, or repeaters for wired connection to DDC controllers.
 - b. Intended for use in applications controlling indoor, conditioned space.
6. Performance:
 - a. Battery Life: [3][5] years when operating under planned use.
 - b. Relative Humidity:
 - 1) Accuracy: [2][3]<Insert value> percent relative humidity.
 - 2) Calibrated Range: [20 to 80][10 to 90]<Insert range> percent relative humidity.
 - c. Temperature:
 - 1) Accuracy: [0.54 deg F (0.3 deg C)][1.0 deg F (0.6 deg C)]<Insert temperature>.
 - 2) Measured Range: [32 to 104 deg F (0 to 40 deg C)][32 to 122 deg F (0 to 50 deg C)]<Insert temperature range>.
 - 3) Ambient Operating Range: [32 to 104 deg F (0 to 40 deg C)]<Insert temperature range>.
 - d. Radio Frequency (RF) Transmission:
 - 1) Frequency: Nominal [900 MHz][or][2.4 GHz].
 - 2) Interval: Maximum of [90]<Insert value> seconds between individual temperature sensor signals sent to DDC controllers.
 - 3) Range: Horizontal line of sight not less than [100 ft. (30 m)][200 ft. (60 m)][300 ft. (90 m)]<Insert distance>.
 - 4) Regulations: Comply with FCC regulations for low power unlicensed transmitters.
7. Analog Output Signal:

- a. Relative Humidity: **[4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>**.
- b. Temperature: **[Temperature sensor resistance (ohms)][4 to 20 mA][or][0 to 10 V dc]<Insert signal requirements>**.
8. Network Communication Interface: **[BACnet MS/TP][or][Modbus RTU]<Insert network protocol>**.
9. Relative Humidity Sensor Type: Manufacturer's choice of sensor type to achieve performance indicated.
10. Temperature Sensor Type: **[1000-ohm platinum RTD][or][10000-ohm, Type II negative temperature coefficient (NTC) thermistor][Manufacturer's choice of sensor type to achieve performance indicated]**.
11. Enclosure:
 - a. Material: Plastic; bright white, non-yellowing.
 - b. Rating: NEMA 250, Type 1.
12. Additional Features: Where indicated for space applications, include temperature and relative humidity sensor with the following features:
 - a. Battery Level Display: LED to indicate need for replacement.
 - b. Transmission Signal Display: LED to indicate signal trouble.
 - c. Relative Humidity Display: Backlit LCD display of percent relative humidity.
 - d. Temperature Display: Backlit LCD display of temperature in metric (SI) or imperial (IP) units.
 - e. Occupancy Override: Local adjustment on face of enclosure for occupant to initiate zone HVAC operation.
 - f. Temperature Set Point: Local adjustment on face of enclosure for occupant to adjust zone temperature set point.
 - g. Occupancy Detector: Sensor with integral PIR-type occupancy detector.
 - h. **<Insert feature>**.
13. Mounting: **[Screw mount][magnets, double-sided foam back tape or Velcro]**; compatible with mounting surface.

2.6 COMBINATION AIR TEMPERATURE SENSORS AND SWITCHES

A. Combination Platinum RTD Air Temperature Sensors and Switches:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Minco]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Minco]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all combination air temperature sensors and switches from a single manufacturer.

4. Description: Combination air temperature sensor and low-temperature switch in same instrument.
5. Standards: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Air Temperature Switch:
 - a. Factory preset set point of **38 deg F (3 deg C)**. Field-adjustable set point from **30 to 44 deg F (minus 1 to 7 deg C)**.
 - b. Responsive to coldest **12-inch (300-mm)** section of sensor length.
 - c. Accuracy: Within **0.9 deg F (0.5 deg C)**.
 - d. DPDT latching relay rated at 6 A and 120 V ac, with powered controller, coil, and local manual rest. **[Wire one leg to fan start circuit and other leg to signal a remote alarm.]**
7. Air Temperature Sensor:
 - a. Temperature-averaging type over sensor length. Length to be determined by installing trade to provide uniform coverage over air tunnel. Consult manufacturer for recommendations.
 - b. Platinum RTDs with a resistance of 1000 ohms at 0 deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
 - c. Temperature Range: **Minus 50 to 176 deg F (Minus 46 to 80 deg C)**.
 - d. Accuracy: At **32 deg F (0 deg C)** within **0.54 deg F (0.3 deg C)**.
 - e. Encase RTDs in a flexible nominal **0.375-inch- (9-mm-)** diameter sheath constructed of aluminum **[or galvanized steel armor with PVC coating]**.
8. Analog Output Signal: Include integral transmitter with 4 to 20 mA signal for connection to remote monitoring.
9. Enclosure:
 - a. Material: Plastic with removable or hinged clear plastic cover.
 - b. Rating: NEMA 250, **[Type 4][or][Type 4X]<Insert type>**.
 - c. Wiring Connection: Terminal block.
10. Status LEDs: LEDs to indicate status of electrical power and fault.

2.7 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low-Temperature Control in Duct Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Dynacon Inc.]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Schneider Electric USA, Inc.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **[Veris Industries]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Belimo Aircontrols (USA), Inc]**
 - b. **[Dynacon Inc.]**
 - c. **[Greystone Energy Systems, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Schneider Electric USA, Inc.]**
 - g. **[Siemens Industry, Inc., Building Technologies Division]**
 - h. **[Veris Industries]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all thermostat and switch for low-temperature control in duct applications from a single manufacturer.
 4. Description:
 - a. Two-position control to open control circuit when temperature is below set point.
 - b. Field-adjustable set point.
 - c. Reset: **[Automatic][or][Manual]**.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 5. Performance:
 - a. Operating Temperature Range: **[15 to 55 deg F (Minus 9 to 13 deg C)]<Insert temperature range>**.
 - b. Temperature Differential: **[2 deg F (1 deg C)][5 deg F (2.8 deg C)]<Insert temperature>**, nonadjustable and additive.
 - c. Enclosure Ambient Temperature: **[Minus 20 to 140 deg F (Minus 11 to 60 deg C)][20 to 140 deg F (Minus 7 to 60 deg C)]<Insert temperature range>**.
 - d. Sensing Element Maximum Temperature: **[140 deg F (60 deg C)][250 deg F (121 deg C)]<Insert temperature>**.
 - e. Voltage: 120 V ac.
 - f. Current: **[10][16]<Insert value> FLA**.
 - g. Switch Type: Two SPDT snap switches operate on coldest **12-inch (300-mm)** section along element length.
 6. Construction:
 - a. Vapor-Filled Sensing Element: Nominal **[10 ft. (3 m)][20 ft. (6 m)][or][50 ft. (15 m)]** long; quantity and length of elements as required by application to account for temperature variations across entire cross section of air tunnel.
 - b. Temperature Scale: **[Fahrenheit][and][Celsius]** visible on face.
 - c. Set-Point Adjustment: Screw.
 - d. Enclosure: Painted metal or plastic, NEMA 250, **[Type 1][or][Type 4]<Insert type>**.
 - e. Electrical Connections: Screw terminals.
 - f. Conduit Connection: **1/2-inch (16-mm)** trade size.
 - g. Mounting Clips: Copper-clad mounting clips with formed radius intended for serpentine coverage across coil face area.

B. Thermostat and Switch for High-Temperature Control in Duct Applications:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- a. **[Greystone Energy Systems, Inc.]**
 - b. **[Schneider Electric USA, Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Greystone Energy Systems, Inc.]**
 - b. **[Schneider Electric USA, Inc.]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all thermostat and switches for high-temperature control from a single manufacturer.
4. Description:
 - a. Two-position control to open control circuit when temperature rises above set point.
 - b. Field-adjustable set point.
 - c. **[Automatic][or][manual]** reset.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Performance:
 - a. Temperature Range: **[100 to 140 deg F (38 to 60 deg C)][100 to 160 deg F (38 to 71 deg C)][100 to 212 deg F (38 to 100 deg C)]<Insert temperature range>**.
 - b. Temperature Differential: **[5 deg F (2.8 deg C)][10 deg F (5.6 deg C)]<Insert temperature>**.
 - c. Ambient Temperature: **[14 to 122 deg F (Minus 10 to 50 deg C)][0 to 260 deg F (Minus 18 to 127 deg C)]<Insert temperature range>**.
 - d. Voltage: **[120 V ac][240 V ac]<Insert voltage>**.
 - e. Current: **[5 FLA][16 FLA]<Insert current>**.
6. Construction:
 - a. Sensing Element: **[Helical bimetal][or][10000-ohm, Type II, NTC thermistor]**.
 - b. Switch Type: SPDT snap switch.
 - c. Enclosure Material: Metal or plastic.
 - d. Enclosure Rating: NEMA 250, **[Type 1][or][Type 4X]<Insert type>**.
 - e. Electrical Connections: Screw terminals.
 - f. Conduit Connection: **1/2-inch (16-mm)** trade size.

2.8 AIR TEMPERATURE RTD TRANSMITTERS

A. Air Temperature RTD Transmitters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Minco]
 - j. [Schneider Electric USA, Inc.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. [Vaisala]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Minco]
 - j. [Schneider Electric USA, Inc.]
 - k. [Siemens Industry, Inc., Building Technologies Division]
 - l. [Vaisala]
 - m. <Insert manufacturer's name>
3. Source Limitations: Obtain air temperature RTD transmitters from same manufacturer as air temperature RTD sensors.
4. Factory Calibration: Factory calibrate each instrument to [NIST-]traceable standards and include instrument with a calibration certificate.
5. If transmitter is not integral with sensor enclosure, house transmitter electronics in NEMA 250 enclosure based on physical location and application.
 - a. Duct: [Type 1][Type 2][Type 3][Type 4][or][Type 4X]<Insert type>.
 - b. Outdoor: [Type 4][or][Type 4X]<Insert type>.
 - c. Space: Type 1.
6. Conduit Connection: 1/2-inch (16-mm) trade size.
7. Functional Characteristics:
 - a. Input:
 - 1) 100-ohm platinum RTD with a temperature coefficient of resistance (TCR) of 0.00385 ohm/ohm/deg C, two-wire sensors.
 - 2) 1000-ohm platinum RTD with a temperature coefficient of resistance (TCR) of 0.00385 ohm/ohm/deg C, two-wire sensors.
 - b. Span (Adjustable):
 - 1) Space: [40 to 90 deg F (4 to 32 deg C)]<Insert temperature span>.

- 2) Supply Air Cooling and Heating: [40 to 120 deg F (4 to 49 deg C)]<Insert temperature span>.
 - 3) Supply Air Cooling Only: [40 to 90 deg F (4 to 32 deg C)]<Insert temperature span>.
 - 4) Supply Air Heating Only: [40 to 120 deg F (4 to 49 deg C)]<Insert temperature span>.
 - 5) Exhaust Air from Conditioned Space: [50 to 100 deg F (10 to 38 deg C)]<Insert temperature span>.
 - 6) Exhaust Air from Unconditioned Space: [40 to 120 deg F (4 to 49 deg C)]<Insert temperature span>.
 - 7) Return Air: [50 to 100 deg F (10 to 38 deg C)]<Insert temperature span>.
 - 8) Mixed Air: [Minus 40 to 140 deg F (Minus 40 to 60 deg C)]<Insert temperature span>.
 - 9) Outdoor: [Minus 40 to 140 deg F (Minus 40 to 60 deg C)]<Insert temperature span>.
 - 10) <Insert application with temperature span>.
- c. Minimum Span: [50 deg F (28 deg C)]<Insert temperature>.
 - d. Field Adjustments: Zero and span, plus or minus [5]<Insert value> percent of span.
 - e. Transmitter required for each 100-ohm RTD.
 - f. Transmitter optional for 1000-ohm RTD, contingent on compliance with system end-to-end control accuracy.
 - g. Analog Output Signal:
 - 1) Current: 4 to 20 mA dc, linear with temperature; radio-frequency-interference insensitive; minimum drive load of [600]<Insert value> ohms at 24 V dc.
 - 2) Voltage: [0 to 5][0 to 10] V dc, linear with temperature.
8. Performance Characteristics:
- a. Calibration Accuracy: Within [0.1][0.2]<Insert value> percent of the span.
 - b. Stability: Within [0.2]<Insert value> percent of the span for at least six months.
 - c. Combined Accuracy: Within [0.5]<Insert value> percent.
9. Factory Match: Match sensor with temperature transmitter and factory calibrate together.

2.9 LIQUID AND STEAM TEMPERATURE SENSORS

A. Platinum RTD Immersion Temperature Sensors, Commercial Grade:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Schneider Electric USA, Inc.]

- j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain all platinum RTD immersion commercial-grade temperature sensors from a single manufacturer.
 4. Factory Calibration: Factory calibrate each instrument to **[NIST-]**traceable standards and include instrument with a calibration certificate.
 5. Performance Characteristics:
 - a. Resistance: **[100][or][1000]** ohms.
 - b. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/ohm/deg C.
 - c. Temperature Range: **[Minus 40 to 210 deg F (Minus 40 to 99 deg C)]<Insert temperature range>**.
 - d. Interchangeable Accuracy: Within **[0.54 deg F (0.3 deg C) at 32 deg F (0 deg C)]<Insert temperatures>**.
 - e. Rated for system pressure, temperature, and velocity.
 6. Output Signal: Resistance in ohms.
 7. Sensor Assembly:
 - a. Probe: Single RTD wired within a rigid stainless steel sheath with a **0.25-inch (6-mm)** OD.
 - b. Immersion Depth: **2, 2-1/2, 4, 6, or 8 inches (50, 65, 100, 150, or 200 mm)** as required by application.
 - c. Process Connection: Threaded, **NPS 1/2 (DN 15)**.
 - d. Two- or three-stranded copper lead wires.
 8. Enclosure:
 - a. Material: Metal **[or plastic]** box with removable cover.
 - b. Rating: NEMA 250, **[Type 3R][Type 4][or][Type 4X]<Insert type>**.
 - c. Conduit Connection: **1/2-inch (16-mm)[or 3/4-inch (20-mm)]** trade size.
- B. Thermistor Immersion Temperature Sensors, Commercial Grade:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**

- b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Schneider Electric USA, Inc.]
 - j. [Siemens Industry, Inc., Building Technologies Division]
 - k. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Schneider Electric USA, Inc.]
 - j. [Siemens Industry, Inc., Building Technologies Division]
 - k. <Insert manufacturer's name>
3. Source Limitations: Obtain all thermistor immersion commercial-grade temperature sensors from a single manufacturer.
4. Factory Calibration: Factory calibrate each instrument to [NIST-]traceable standards and include instrument with a calibration certificate.
5. Description:
6. Performance Characteristics:
 - a. Temperature Drift: Within [0.5 deg F (0.3 deg C)][1.0 deg F (0.6 deg C)]<Insert temperature> over [10]<Insert value> years.
 - b. Temperature Range: [32 to 158 deg F (0 to 99 deg C)][Minus 40 to 210 deg F (Minus 40 to 99 deg C)]<Insert temperature range>.
 - c. Interchangeable Accuracy: Within [0.18 deg F (0.1 deg C) at 77 deg F (25 deg C)][0.36 deg F (0.2 deg C) at 77 deg F (25 deg C)]<Insert temperatures>.
 - d. Rated for system pressure, temperature and velocity.
7. Output Signal: Resistance in ohms.
8. Thermistor: 10000-ohm, Type II, negative temperature coefficient (NTC).
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
9. Sensor Assembly:
 - a. Probe: Single thermistor wired within a rigid stainless steel sheath with a 0.25-inch (6-mm) OD.
 - b. Immersion Depth: 2, 2-1/2, 4, 6, or 8 inches (50, 65, 100, 150, or 200 mm) as required by application.
 - c. Process Connection: Threaded, NPS 1/2 (DN 15).

- d. Two- or three-stranded copper lead wires.
10. Enclosure:
- a. Material: Metal **[or plastic]** box with removable cover.
 - b. Rating: NEMA 250, **[Type 3R][Type 4][or][Type 4X]<Insert type>**.
 - c. Conduit Connection: **1/2-inch (16-mm)[or 3/4-inch (20-mm)]** trade size.
- C. Thermowells, Commercial Grade:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain thermowells from same manufacturer as liquid and steam commercial-grade temperature sensors.
 - 4. Performance: Rated for system pressure, temperature and velocity.
 - 5. Thermowell:
 - a. Material: **[Brass][or][stainless steel]**.
 - b. Process Connection: Threaded, **NPS 1/2 (DN 15) or NPS 3/4 (DN 20)**.
 - c. Sensor Connection: Threaded, **NPS 1/2 (DN 15)**.
 - d. Stem: **[Straight][or][stepped]** shank formed from solid bar stock.
 - e. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
 - f. Extended Neck: Furnish thermowells installed in insulated pipes and equipment with an extended neck.
 - g. Immersion Length: **2, 2-1/2, 4 , 6, or 8 inches (50, 65 , 100, 150, or 200 mm)** as required

by application.

6. Furnish thermowells with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.
7. Factory Assembly: Sensor manufacturer is to furnish sensor and thermowell to provide a matched assembly.

D. Platinum RTD Immersion Temperature Sensors, High-End Commercial Grade:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Minco]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Minco]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain all platinum RTD immersion high-end commercial-grade temperature sensors from a single manufacturer.
4. Factory Calibration: Factory calibrate each instrument to traceable standards and include instrument with a calibration certificate.
5. Standards: Comply with IEC 60751, Class **[A][or][B]** requirements.
6. Performance Characteristics:
 - a. Temperature Range: **Minus 58 to 500 deg F (Minus 50 to 260 deg C).**
 - b. Interchangeable Accuracy: Within **[0.27 deg F (0.15 deg C)][0.54 deg F (0.3 deg C)]** at **32 deg F (0 deg C).**
 - c. Time Constant: 1.5 seconds with water flowing across sensor.
7. Sensor Assembly:
 - a. RTD: Platinum with a value of 100 ohms at 0 deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
 - b. Probe: Encase RTD in a Type 316 stainless steel sheath with a **0.25-inch (8-mm)** OD.
 - c. Wire: **[two][three][four]**-wire, PTFE-insulated, nickel-coated, 22-gauge, stranded copper leads.
 - d. Provide spring-loaded RTDs for thermowell installations.

E. Thermowells, High-End Commercial Grade:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Minco]**
 - b. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Minco]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain high-end commercial-grade thermowells from same manufacturer as liquid and steam high-end commercial-grade temperature sensors.
4. Performance: Rated for system pressure, temperature, and velocity.
5. Thermowell:
 - a. Material: **[Type 304][or][Type 316]** stainless steel.
 - b. Process Connection: Threaded, **NPS 1/2 (DN 15)** or **NPS 3/4 (DN 20)**.
 - c. Sensor Connection: Threaded, **NPS 1/2 (DN 15)**.
 - d. Stem: **[Straight][Stepped][or][tapered]** shank formed from solid bar stock.
 - e. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
 - f. Extended Neck: Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends the threaded sensor connection beyond the face of the insulation covering.
 - g. Immersion Length: As required by application and pipe size.
 - h. Furnish thermowells with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

F. Connection Heads, High-End Commercial Grade:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Minco]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Minco]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain high-end commercial-grade connection heads from same manufacturer as liquid and steam high-end commercial-grade temperature sensors.
4. Housing: Low-copper cast-aluminum alloy or Type 316 stainless steel, complying with NEMA 250, **[Type 4][or][Type 4X]<Insert type>**.
5. Terminals: Six or eight as required by sensor.
6. Conduit Connection: **1/2-inch (16-mm)** trade size.
7. Sensor Connection: **NPS 1/2 (DN 15)**.
8. Factory Assembly: Sensor manufacturer is to furnish sensor, thermowell, and sensor connection head to provide a matched assembly.

G. Platinum RTD Immersion Temperature Sensor, Industrial Grade:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [Burns Engineering]
 - b. [Honeywell Process Solutions]
 - c. [Rosemount; Emerson Electric Co., Automation Solutions]
 - d. [Siemens]
 - e. [Yokogawa]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Burns Engineering]
 - b. [Honeywell Process Solutions]
 - c. [Rosemount; Emerson Electric Co., Automation Solutions]
 - d. [Siemens]
 - e. [Yokogawa]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain all platinum RTD immersion industrial-grade temperature sensors from a single manufacturer.
4. Factory Calibration: Factory calibrate each instrument to traceable standards and include instrument with a calibration certificate.
5. Standards: Comply with IEC 60751, Class A requirements.
6. Performance:
 - a. Temperature Range: [Minus 58 to 500 deg F (Minus 50 to 260 deg C)][Minus 58 to 842 deg F (Minus 50 to 450 deg C)]<Insert temperature range>.
 - b. Interchangeable Accuracy: Within [0.27 deg F (0.15 deg C) at 32 deg F (0 deg C)]<Insert temperature>.
 - c. Hysteresis: Within [0.04]<Insert value> percent of range.
 - d. Stability: [Within 0.05 percent maximum ice-point resistance shift after 1000 hours at 752 deg F (400 deg C)]<Insert requirement>.
 - e. Response Time: [62.8 percent of change in four seconds with water flowing across sensor at 3 fps (0.9 m/s)]<Insert requirement>.
 - f. Self-Heating: [18 mW minimum power dissipation required to cause a 1.8 deg F (1 deg C) temperature measurement error in water flowing at 3 fps (0.9 m/s)]<Insert requirement>.
7. Sensor Assembly:
 - a. RTD: Platinum with a value of 100 ohms at 0 deg C and a temperature coefficient of resistance (TCR) of 0.00385 ohm/ohm/deg C.
 - b. Probe: Encase RTD in a Type 316, Type 316L, or Type 321 stainless steel sheath with a 0.25-inch (8-mm) OD.
 - c. Wire: Provide [two][three][four]-wire, PTFE-insulated, nickel-coated, 22-gauge, stranded copper leads.
 - d. Provide sensor assembly with spring-loaded tip for thermowell installations.
- H. Thermowells, Industrial Grade:
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the

following]:

- a. [Burns Engineering]
 - b. [Honeywell Process Solutions]
 - c. [Rosemount; Emerson Electric Co., Automation Solutions]
 - d. [Siemens]
 - e. [Yokogawa]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Burns Engineering]
 - b. [Honeywell Process Solutions]
 - c. [Rosemount; Emerson Electric Co., Automation Solutions]
 - d. [Siemens]
 - e. [Yokogawa]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain industrial-grade thermowells from same manufacturer as liquid and steam industrial-grade temperature sensors.
4. Performance: Rated for system pressure, temperature, and velocity.
5. Thermowell Construction:
 - a. Stem: [Straight][stepped][or][tapered] shank formed from solid bar stock.
 - b. Material: [Type 304][Type 304L][Type 316][or][Type 316L]<Insert type> stainless steel.
 - c. Process Connection:
 - 1) Threaded: **NPS 3/4 (DN 20)**.
 - 2) Flange-face, where indicated: [NPS 1 (DN 25)][NPS 1-1/2 (DN 38)][NPS 2 (DN 50)], ASME B16.5, [Class 150][Class 300].
 - d. Sensor Connection: Threaded, **NPS 1/2 (DN 15)**.
 - e. Bore: Size to accommodate sensor stem OD with tight tolerance between sensor and well.
 - f. Head (Neck) Extension: Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends the threaded sensor connection beyond the face of the insulation covering.
 - g. Immersion Length: As required by application and pipe size.
 - h. Furnish thermowells with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.
- I. Connection Heads, Industrial Grade:
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Burns Engineering]
 - b. [Honeywell Process Solutions]
 - c. [Rosemount; Emerson Electric Co., Automation Solutions]
 - d. [Siemens]
 - e. [Yokogawa]
 - f. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Burns Engineering]**
 - b. **[Honeywell Process Solutions]**
 - c. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - d. **[Siemens]**
 - e. **[Yokogawa]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain industrial-grade connection heads from same manufacturer as liquid and steam industrial-grade temperature sensors.
4. Housing: Low-copper cast-aluminum alloy or stainless steel, complying with NEMA 250, **[Type 4][or][Type 4X]<Insert type>**.
5. Terminals: Six or eight as required by sensor, nickel-plated brass.
6. Conduit Connection: **1/2-inch (16-mm)** trade size.
7. Sensor Connection: Threaded, **NPS 1/2 (DN 15)**.
8. Factory Assembly: Sensor manufacturer is to furnish sensor, thermowell, and sensor connection head to provide a matched assembly.

2.10 STRAP-ON TEMPERATURE SENSORS FOR PIPING

A. Platinum RTD Strap-on Temperature Sensors for Piping:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**

- i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain all platinum RTD strap-on temperature sensors for piping from a single manufacturer.
 4. Factory Calibration: Factory calibrate each instrument to **[NIST-]**traceable standards and include instrument with a calibration certificate.
 5. Description: Nonintrusive temperature sensor for pipe applications.
 6. Performance:
 - a. Accuracy: Within **[0.27 deg F (0.15 deg C) at 32 deg F (0 deg C)]<Insert temperatures>**.
 - b. Resistance: **[100][or][1000]<Insert value>** ohms.
 - c. Response Time: Within **[30]<Insert value>** seconds for a **[60]<Insert value>** percent step change.
 - d. Self-Heating: 18 mW minimum power dissipation
 - e. Stability: Within **[0.03]<Insert value>** percent after 1000 hours at maximum temperature in range.
 - f. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/ohm/deg C.
 - g. Fluid Temperature Range: As required by application, not less than **[Minus 40 to 185 deg F (Minus 45 to 85 deg C)]<Insert temperature range>**.
 - h. Ambient Temperature Range: As required by application, not less than **[Minus 40 to 122 deg F (Minus 40 to 50 deg C)]<Insert temperature range>**.
 7. Output Signal: Resistance in ohms.
 8. Sensor Assembly:
 - a. Sensing Plate: RTD bonded or encapsulated to the back side of **[an aluminum][a brass][or][copper]** heat sink for direct contact with outside surface of pipe.
 - b. Clamp: Adjustable stainless steel hose clamp with quick-release worm gear.
 - c. Pipe Size Range: **[NPS 3/4 (DN 20)]<Insert pipe size>** through **[NPS 10 (DN 250)]<Insert pipe size>**.
 9. Enclosure:
 - a. Material: Painted or galvanized metal **[or plastic]** box with removable cover.
 - b. Rating: NEMA 250, **[Type 1][Type 4][or][Type 4X]<Insert type>**.
 10. Conduit Connection: **1/2-inch (16-mm)[or 3/4-inch (20-mm)]** trade size.
 11. Wiring Connection:
 - a. Two- **[or three-]** wire, PTFE-insulated, minimum 22-gauge stranded copper leads.
 - b. Terminal Strip: Labeled terminal strip for connection to field wiring.
 12. Heat-Transfer Paste: Include each temperature sensor with heat-transfer paste.
- B. Thermistor Strap-on Temperature Sensors for Piping:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**

- d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Schneider Electric USA, Inc.]
 - j. [Siemens Industry, Inc., Building Technologies Division]
 - k. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ACI Automation; Automation Components Inc]
 - b. [Belimo Aircontrols (USA), Inc]
 - c. [Building Automation Products Inc.; BAPI]
 - d. [Dwyer Instruments, Inc]
 - e. [Greystone Energy Systems, Inc.]
 - f. [Honeywell International Inc.]
 - g. [Johnson Controls, Inc.]
 - h. [MAMAC Systems, Inc.]
 - i. [Schneider Electric USA, Inc.]
 - j. [Siemens Industry, Inc., Building Technologies Division]
 - k. <Insert manufacturer's name>
 3. Source Limitations: Obtain all platinum thermistor strap-on temperature sensors for piping from a single manufacturer.
 4. Factory Calibration: Factory calibrate each instrument to [NIST]-traceable standards and include instrument with a calibration certificate.
 5. Description: Nonintrusive temperature sensor for pipe applications.
 6. Performance:
 - a. Accuracy: Within [0.36 deg F (0.20 deg C) at 32 deg F (0 deg C)]<Insert temperatures>.
 - b. Response Time: Within [30]<Insert value> seconds for a [60]<Insert value> percent step change.
 - c. Self-Heating: Negligible.
 - d. Stability: Within [0.03]<Insert value> percent after 1000 hours at maximum temperature in range.
 - e. Fluid Temperature Range: As required by application, not less than [Minus 40 to 185 deg F (Minus 45 to 85 deg C)]<Insert temperature range>.
 - f. Ambient Temperature Range: As required by application, not less than [Minus 40 to 122 deg F (Minus 40 to 50 deg C)]<Insert temperature range>.
 7. Output Signal: Resistance in ohms.
 8. Thermistor: 10000-ohm, Type II, negative temperature coefficient (NTC).
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
 9. Sensor Assembly:
 - a. Sensing Plate: Thermistor bonded or encapsulated to the back side of [an aluminum][a brass][or][copper] heat sink for direct contact with outside surface of pipe.
 - b. Clamp: Adjustable stainless steel hose clamp with quick-release worm gear.
 - c. Pipe Size Range: [NPS 3/4 (DN 20)]<Insert pipe size> through [NPS 10 (DN 250)]<Insert

pipe size>.

10. Enclosure:
 - a. Material: Painted or galvanized metal[**or plastic**] box with removable cover.
 - b. Rating: NEMA 250, [Type 1][Type 4][or][Type 4X]<Insert type>.
11. Conduit Connection: **1/2-inch (16-mm)[or 3/4-inch (20-mm)]** trade size.
12. Wiring Connection:
 - a. Two-wire, PTFE-insulated, minimum 22-gauge stranded copper leads.
 - b. Terminal Strip: Labeled terminal strip for connection to field wiring.
13. Heat-Transfer Paste: Include each temperature sensor with heat-transfer paste.

2.11 LIQUID TEMPERATURE SWITCHES

A. Thermostat and Switch for Temperature Control in Pipe Applications:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Honeywell International Inc.]
 - b. [Penn Controls]
 - c. [Siemens]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Honeywell International Inc.]
 - b. [Penn Controls]
 - c. [Siemens]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain all thermostats and switches for temperature control in piping applications from a single manufacturer.
4. Description:
 - a. Two-position control.
 - b. Field-adjustable set point.
 - c. Manual reset.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Performance:
 - a. Operating Temperature Range: [65 to 200 deg F (18 to 93 deg C)][100 to 240 deg F (40 to 120 deg C)].
 - b. Temperature Differential Deadband: [5 to 30 deg F (3 to 17 deg C)] [6 to 24 deg F (3.3 to 13 deg C)], adjustable.
 - c. Enclosure Ambient Temperature: [140 deg F (60 deg C)][150 deg F (66 deg C)].

- d. Sensing Element Pressure Rating: **200 psig (1379 kPa)**.
 - e. Voltage: 120 V ac.
 - f. Current: **[8][10]<Insert value> FLA**.
 - g. Switch Type: SPDT snap switch.
6. Construction:
- a. Vapor-filled immersion element.
 - b. Temperature Scale: Fahrenheit, visible on face.
 - c. Set-Point Adjustment: Screw or rotary knob.
 - d. Enclosure: Painted metal, NEMA 250, Type 1.
 - e. Electrical Connections: Screw terminals.
 - f. Conduit Connection: **1/2-inch (16-mm) or 3/4-inch (20-mm)** trade size.

2.12 LIQUID AND STEAM TEMPERATURE TRANSMITTERS

A. Liquid and Steam Temperature Transmitters, Commercial Grade:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ACI Automation; Automation Components Inc]**
 - b. **[Belimo Aircontrols (USA), Inc]**
 - c. **[Building Automation Products Inc.; BAPI]**
 - d. **[Dwyer Instruments, Inc]**
 - e. **[Greystone Energy Systems, Inc.]**
 - f. **[Honeywell International Inc.]**
 - g. **[Johnson Controls, Inc.]**
 - h. **[MAMAC Systems, Inc.]**
 - i. **[Schneider Electric USA, Inc.]**
 - j. **[Siemens Industry, Inc., Building Technologies Division]**
 - k. **<Insert manufacturer's name>**
3. Source Limitations: Obtain liquid and steam temperature transmitters from same manufacturer as liquid and steam temperature RTD sensors.
4. Factory Calibration: Factory calibrate each instrument to **[NIST-]**traceable standards and include

- instrument with a calibration certificate.
5. Performance Characteristics:
 - a. Calibration Accuracy: Within **[0.2]<Insert value>** percent of the span.
6. Functional Characteristics:
 - a. Input: 100-ohm platinum RTD with temperature coefficient of 0.00385 ohm/ohm/deg C; **[two-][or][three-]**wire sensors.
 - b. Default Span (Adjustable):
 - 1) Chilled Water: **[0 to 100 deg F (Minus 18 to 38 deg C)]<Insert temperature range>**.
 - 2) Condenser Water: **[0 to 120 deg F (Minus 18 to 49 deg C)]<Insert temperature range>**.
 - 3) Heating Hot Water: **[32 to 212 deg F (0 to 100 deg C)]<Insert temperature range>**.
 - 4) Heat Recovery: **[0 to 120 deg F (Minus 18 to 49 deg C)]<Insert temperature range>**.
 - 5) **<Insert system and span>**.
 - c. Minimum Span: **[50 deg F (28 deg C)]<Insert temperature>**.
 - d. Field Adjustments: Span.
7. Analog Output Signal: 4 to 20 mA dc, linear with temperature; radio-frequency-interference insensitive; minimum drive load of **[600]<Insert value>** ohms at 24 V dc.
8. Electronics Enclosure:
 - a. Rating: NEMA 250, **[Type 3R][Type 4][or][Type 4X]**.
 - b. Conduit Connection: **1/2-inch (16-mm)[or 3/4-inch (20-mm)]** trade size.
 - c. Wiring Connection: Labeled terminals.
9. Factory Match: Factory match sensor with temperature transmitter.
- B. Liquid and Steam Temperature Transmitters, High-End Commercial Grade:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Minco]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Minco]**
 - b. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain liquid and steam temperature transmitters from same manufacturer as liquid and steam temperature RTD sensors.
 4. Factory Calibration: Factory calibrate each instrument to **[NIST-]**traceable standards and include instrument with a calibration certificate.
 5. Performance Characteristics:

-
- a. Calibration Accuracy: Within **[0.1]<Insert value>** percent of the span.
 - 6. Functional Characteristics:
 - a. Input: 100-ohm platinum RTD with temperature coefficient of 0.00385 ohm/ohm/deg C; **[two-][or][three-]**wire sensors.
 - b. Default Span (Adjustable):
 - 1) Chilled Water: **[0 to 100 deg F (Minus 18 to 38 deg C)]<Insert temperature range>**.
 - 2) Condenser Water: **[0 to 120 deg F (Minus 18 to 49 deg C)]<Insert temperature range>**.
 - 3) Heating Hot Water: **[32 to 212 deg F (0 to 100 deg C)]<Insert temperature range>**.
 - 4) Heat Recovery: **[0 to 120 deg F (Minus 18 to 49 deg C)]<Insert temperature range>**.
 - 5) **<Insert system and span>**.
 - c. Minimum Span: **[18 deg F (10 deg C)]<Insert temperature>**
 - d. Field Adjustments: Zero and span adjustments, plus or minus **[5]<Insert value>** percent of span.
 - 7. Analog Output Signal: 4 to 20 mA dc, linear with temperature; radio-frequency-interference insensitive; minimum drive load of **[600]<Insert value>** ohms at 24 V dc.
 - 8. Electronics Enclosure:
 - a. Material: Painted aluminum alloy.
 - b. Rating: NEMA 250, **[Type 4][or][Type 4X]**.
 - c. Conduit Connection: **1/2-inch (16-mm)[or 3/4-inch (20-mm)]** trade size.
 - d. Wiring Connection: Labeled terminals.
 - e. Display: Head mounted; display of temperature in **[degrees C][degrees F]**.
 - 9. Factory Match: Factory match sensor with temperature transmitter.
 - C. Liquid and Steam Temperature Transmitters, Industrial Grade:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Honeywell Process Solutions]**
 - b. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - c. **[Siemens]**
 - d. **[Yokogawa]**
 - e. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Honeywell Process Solutions]**
 - b. **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - c. **[Siemens]**
 - d. **[Yokogawa]**

- e. <Insert manufacturer's name>
3. Source Limitations: Obtain liquid and steam temperature transmitters from same manufacturer as liquid and steam temperature RTD sensors.
 4. Factory Calibration: Factory calibrate each instrument to [NIST-]traceable standards and include instrument with a calibration certificate.
 5. Hazard Classification: Where indicated, provide instrument that is FM Approved for hazardous environments.
 - a. Intrinsically safe for Classes I, II, and III; Division 1; Groups A through G.
 - b. Explosion proof for Class I; Division 1; Groups B, C, and D.
 - c. Dust-ignition proof for Classes II and III; Division 1; Groups E, F, and G.
 6. Performance:
 - a. Digital Accuracy: Within 0.18 deg F (0.1 deg C) <Insert temperature>.
 - b. Digital to Analog Accuracy: Within [0.005][0.03]<Insert value> percent of span.
 - c. Total Accuracy: Within [0.23 deg F (0.18 deg C)][0.32 deg F (0.18 deg C)]<Insert temperature> with a [180 deg F (82 deg C)]<Insert temperature>.
 - d. Stability: Within [0.15]<Insert value> percent of output reading for [24]<Insert value> months.
 - e. Ambient Temperature Limits: [Minus 40 to 185 deg F (Minus 40 to 85 deg C)]<Insert temperature range>.
 - f. Humidity Limits: Zero to [99]<Insert value> percent.
 7. Functional Characteristics:
 - a. Range: [Minus 328 to 1562 deg F (Minus 200 to 850 deg C)]<Insert temperature range>.
 - b. Field-Adjustable Span: [1 deg F (0.6 deg C)][18 deg F (10 deg C)]<Insert temperature> minimum.
 - c. Default Spans:
 - 1) Chilled Water: [0 to 100 deg F (Minus 18 to 38 deg C)]<Insert temperature range>.
 - 2) Condenser Water: [0 to 120 deg F (Minus 18 to 49 deg C)]<Insert temperature range>.
 - 3) Heating Hot Water: [32 to 212 deg F (0 to 100 deg C)]<Insert temperature range>.
 - 4) Heat Recovery: [0 to 120 deg F (Minus 18 to 49 deg C)]<Insert temperature range>.
 - 5) <Insert system and span>.
 - d. Output Signal:
 - 1) 4 to 20 mA dc, linear with temperature.
 - 2) Digital signal based on HART protocol carried with current signal.
 - 3) Radio-frequency-interference insensitive.
 - 4) Minimum drive load of [600]<Insert value> ohms at 24 V dc.
 - e. Self-Calibration: The analog-to-digital measurement circuitry automatically self-calibrates for each temperature update by comparing the dynamic measurement to extremely stable and accurate internal reference elements.
 8. Electronics Enclosure:

- a. Materials: **[Aluminum alloy][or][stainless steel]**.
- b. Rating: NEMA 250, Type 4X.
- c. Conduit Connections: **1/2-inch (16-mm)[or 3/4-inch (20-mm)]** trade size.
- d. Wiring Terminals: As required by sensor.
- e. Digital Display: Display of engineering units.
- f. Mounting kit to suit application.

- 9. Factory Match: Factory match sensor with temperature transmitter.

2.13 SOURCE QUALITY CONTROL

- A. Factory Tests and Inspections: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.
- B. Prepare test and inspection reports as applicable.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPERATURE INSTRUMENT APPLICATIONS

- A. Air Temperature Sensors:
 - 1. 100-ohm Platinum RTD, Single-Point Air Temperature Duct Sensors: **<Insert application>**.
 - 2. 1000-ohm Platinum RTD, Single-Point Air Temperature Duct Sensors: **<Insert application>**.
 - 3. 100-ohm Platinum RTD, Air Temperature Averaging Sensors: **<Insert application>**.
 - 4. 1000-ohm Platinum RTD, Air Temperature Averaging Sensors: **<Insert application>**.
 - 5. 100-ohm Platinum RTD Outdoor Air Temperature Sensors: **<Insert application>**.
 - 6. 1000-ohm Platinum RTD Outdoor Air Temperature Sensors: **<Insert application>**.
 - 7. 100-ohm Platinum RTD Space Air Temperature Sensors: **<Insert application>**.
 - 8. 1000-ohm Platinum RTD Space Air Temperature Sensors: **<Insert application>**.
 - 9. 100-ohm Platinum RTD Space Air Temperature Sensors, Flush-Mount, Flat-Face Cover: **<Insert application>**.
 - 10. 1000-ohm Platinum RTD Space Air Temperature Sensors, Flush-Mount, Flat-Face Cover: **<Insert application>**.
 - 11. 100-ohm Platinum RTD Space Air Temperature Sensors, Button Style: **<Insert application>**.

12. 1000-ohm Platinum RTD Space Air Temperature Sensors, Button Style: **<Insert application>**.
 13. 100-ohm Platinum RTD Space Air Temperature Sensors with Occupant Interface Features: **<Insert application>**.
 14. 1000-ohm Platinum RTD Space Air Temperature Sensors with Occupant Interface Features: **<Insert application>**.
 15. Thermistor Single-Point Air Temperature Duct Sensors: **<Insert application>**.
 16. Thermistor Air Temperature Averaging Sensors: **<Insert application>**.
 17. Thermistor Outdoor Air Temperature Sensors: **<Insert application>**.
 18. Thermistor Space Air Temperature Sensors: **<Insert application>**.
 19. Thermistor Space Air Temperature Sensors, Flush-Mount, Flat-Face Cover: **<Insert application>**.
 20. Thermistor Space Air Temperature Sensors, Button Style: **<Insert application>**.
 21. Thermistor Space Air Temperature Sensors with Occupant Interface Features: **<Insert application>**.
- B. Air Temperature Sensors with Network Communication Signal for Space Applications: **<Insert application>**.
- C. Multivariable Air Temperature Sensors and Transmitters:
1. Combination Carbon-Dioxide and Air Temperature Sensors and Transmitters for Duct Applications: **<Insert application>**.
 2. Combination Carbon-Dioxide and Air Temperature Sensors and Transmitters for Space Applications: **<Insert application>**.
 3. Combination Carbon-Dioxide, Relative Humidity, and Air Temperature Sensors and Transmitters for Duct Applications: **<Insert application>**.
 4. Combination Carbon-Dioxide, Relative Humidity, and Temperature Sensors and Transmitters for Space Applications: **<Insert application>**.
- D. Wireless Air Temperature Sensors:
1. Wireless Air Temperature Sensors: **<Insert application>**.
 2. Wireless Air Temperature and Relative Humidity Sensors and Transmitters: **<Insert application>**.
- E. Combination Air Temperature Sensors and Switches: **<Insert application>**.
- F. Air Temperature Switches:
1. Thermostat and Switch for Low-Temperature Control in Duct Applications: **<Insert application>**.
 2. Thermostat and Switch for High-Temperature Control in Duct Applications: **<Insert application>**.
- G. Air Temperature RTD Transmitters: **<Insert application>**.
- H. Liquid and Steam Temperature Sensors, Commercial Grade:
1. 100-ohm Platinum RTD Immersion Temperature Sensors, Commercial Grade: **<Insert application>**.
 2. 1000-ohm Platinum RTD Immersion Temperature Sensors, Commercial Grade: **<Insert application>**.
 3. Thermistor Immersion Temperature Sensors, Commercial Grade: **<Insert application>**.
 4. 100-ohm Platinum RTD Immersion Temperature Sensors, High-End Commercial Grade: **<Insert application>**.
- I. Liquid and Steam Temperature Sensors, High-End Commercial Grade:

1. Platinum RTD Immersion Temperature Sensors, High-End Commercial Grade: **<Insert application>**.
- J. Liquid and Steam Temperature Sensors, Industrial Grade:
 1. Platinum RTD Immersion Temperature Sensors, Industrial Grade: **<Insert application>**.
- K. Strap-on Temperature Sensors for Piping:
 1. Platinum RTD Strap-on Temperature Sensors for Piping: **<Insert application>**.
 2. Thermistor Strap-on Temperature Sensors for Piping: **<Insert application>**.
- L. Liquid Temperature Switches:
 1. Thermostat and Switch for Temperature Control in Pipe Applications: **<Insert application>**.
 2. **<Insert system>** System, **<Insert unique application>**: **[Liquid and steam temperature sensor, Commercial Grade][Liquid and steam temperature sensor, High-End Commercial Grade][Liquid and steam temperature sensor, Industrial Grade]**.
- M. Liquid and Steam Temperature Transmitters, Commercial Grade: **<Insert application>**.
- N. Liquid and Steam Temperature Transmitters, High-End Commercial Grade: **<Insert application>**.
- O. Liquid and Steam Temperature Transmitters, Industrial Grade: **<Insert application>**.

3.3 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.
- C. Fastening Hardware:
 1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- E. Corrosive Environments:
 1. Use products that are suitable for environment to which they are subjected.
 2. If possible, avoid or limit use of materials in corrosive environments.
 3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of **[Type 316L**

stainless steel]<Insert material>.

3.4 INSTALLATION OF TEMPERATURE INSTRUMENTS

A. Mounting Location:

1. Roughing In:

- a. Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
- b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
 - 1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
 - 2) Do not begin installation without submittal approval of mounting location.
- c. Complete installation rough-in only after confirmation by independent inspector is complete and approval of location is documented for review by Owner and Architect on request.

2. Install switches and transmitters for air and liquid temperature associated with individual HVAC equipment and associated connected ductwork and piping near HVAC equipment co-located in HVAC equipment system control panel to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Protect products installed outdoors from solar radiation and building and wind effect with stand-offs and shields constructed of **[Type 316 stainless steel]<Insert material>**.
2. Isolate temperature instruments having performance impacted by temperature of mounting substrate with an insulating barrier located between instrument and substrate to eliminate effect on performance. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height is to comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of **42 to 72 inches (1.1 to 1.6 m)** above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at **60 inches (1500 mm)**.

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Installation of Space Temperature Sensors:

1. Conceal assembly and field wiring connections in an electrical box of sufficient size to house sensor and transmitter, if provided.
2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Installation of Outdoor Air Temperature Sensors:

1. Mount sensor in an accessible and discrete location facing north.
2. Protect installed sensor from solar radiation and other environmental influences that could impact performance.
3. If required to have a transmitter, mount transmitter remotely from sensor in an accessible and serviceable location indoors that is not readily accessible by building occupants.

G. Installation of Single-Point Duct Temperature Sensors:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed near center of duct cross section and located to sense near average temperature. Do not exceed **18 inches (450 mm)** in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remotely from sensor at accessible and serviceable location indoors that is not readily accessible by building occupants.
5. Install duct access doors of sufficient size for inspection, removal, and replacement of single-point duct temperature sensors. Comply with Section 233300 "Air Duct Accessories" for access doors.

H. Installation of Averaging Duct Temperature Sensors:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar HVAC equipment, and large ducts with air tunnel cross-sectional area of **[10 sq. ft. (0.9 sq. m)][20 sq. ft. (1.86 sq. m)]<Insert area>** and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area and measure an average temperature. Install multiple sensors where required to maintain coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor properly supported and taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location indoors that is not readily accessible by building occupants.
5. Install duct access doors of sufficient size for inspection, removal, and replacement of averaging duct temperature sensors. Comply with Section 233300 "Air Duct Accessories" for access doors.

I. Installation of Multivariable Air Temperature Sensors and Transmitters: Comply with requirements indicated for air temperature sensors.

J. Installation of Wireless Air Temperature Sensors:

1. Mount sensors to substrate at height indicated, using mounting kits furnished with sensors.

2. In areas with ceilings, conceal mounting of receivers, transceivers, or repeaters above ceilings.
3. Test communication signal to ensure a strong and uninterrupted signal to all connected devices and for proper coverage. Add additional receivers, transceivers, or repeaters if required.

K. Installation of Combination Air Temperature Sensors and Switches:

1. Install combination air temperature sensors and switches to maintain coverage over entire cross-sectional area of air tunnel and to account for stratification. Install multiple instruments if required to maintain coverage over entire cross-sectional area of air tunnel and to account for stratification.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element properly supported and taut throughout entire length.
3. Mount instrument enclosure outside of airstream at a location and mounting height to provide easy access for set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.
5. Install duct access doors of sufficient size for inspection, removal, and replacement of combination air temperature sensors and switches. Comply with Section 233300 "Air Duct Accessories" for access doors.

L. Installation of Low-Limit Air Temperature Switches:

1. Install low-limit switches to maintain coverage over entire cross-sectional area of air tunnel and to account for stratification. Install multiple switches if required to maintain coverage over entire cross-sectional area of air tunnel and to account for stratification.
2. Fasten and support sensing element with manufacturer-furnished clips to keep sensor properly supported and taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.
5. Install duct access doors of sufficient size for inspection, removal, and replacement of low-limit air temperature switches. Comply with Section 233300 "Air Duct Accessories" for access doors.

M. Installation of Liquid and Steam Temperature Sensors:

1. Install all sensors in a matching thermowell.
2. For pipe **NPS 4 (DN 100)** and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
3. For pipe smaller than **NPS 4 (DN 100)**:
 - a. Install reducers to increase pipe size to **NPS 4 (DN 100)** at point of thermowell installation.
 - b. For pipe sizes **NPS 2-1/2 and NPS 3 (DN 65 and DN 80)**, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
 - c. Minimum insertion depth is to be **2-1/2 inches (65 mm)**.
4. Fill thermowell with heat-transfer compound before inserting sensor.
5. Install tip of spring-loaded sensors to contact inside of thermowell.
6. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
7. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
8. Install sensors and thermowells to provide a leak-free installation when subjected to system, pressures, temperatures, and velocities encountered.
9. Install high-end commercial and industrial grade liquid and steam temperature sensors with a connection head.
10. For applications with transmitters, mount transmitter remotely from sensor in an accessible and serviceable location from floor[**service platform or catwalk**]. Avoid locations that are readily

accessible by building occupants.

3.5 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 260533.23 "Surface Raceways for Electrical Systems."
- E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Furnish and install raceways. Comply with requirements in Section 260533.23 "Surface Raceways for Electrical Systems."

3.7 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification[**and on face of ceiling directly below instruments concealed above ceilings**].

3.8 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.9 CHECK-OUT PROCEDURES

- A. Check installed products before continuity tests, leak tests, and calibration.
- B. Check temperature instruments for proper location and accessibility.
- C. Verify sensing element type and proper material.
- D. Check instruments for proper installation with respect to location, elevation, orientation, insertion depth, or other applicable considerations that impact performance.
- E. Verify that wiring is correct and secure.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

- 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
- 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
- 3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
- 4. Equipment and procedures used for calibration are to meet instrument manufacturer's written instructions.
- 5. Provide diagnostic and test equipment for calibration and adjustment.
- 6. Field instruments and equipment used to test and calibrate installed instruments are to have at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent is to be checked by an instrument with an accuracy of 0.5 percent.
- 7. Calibrate each instrument in accordance with instrument instruction manual supplied by manufacturer.
- 8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
- 9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

- 1. Check analog voltage signals using a voltage meter at zero, 50, and 100 percent.
- 2. Check analog current signals using a current meter at zero, 50, and 100 percent.
- 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

- 1. Check digital signals using a jumper wire.
- 2. Check digital signals using an ohmmeter to test for contact.

- D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- E. Switches: Calibrate switches to make or break contact at set points indicated.
- F. Transmitters:
 - 1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values. **[Field calibration is not required for instruments that have been factory calibrated and provided with certificates.]**
 - 2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.
- C. Tests and Inspections: Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Perform in accordance with manufacturer's written instruction.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.12 ADJUSTING

- A. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.13 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes **[three][six][nine][12]** months' full maintenance by **[skilled employees of systems and equipment Installer][manufacturer's authorized service representative]**. Include **[monthly][quarterly][semiannual][annual]** preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

3.14 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

- B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 09 23 27



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 23 27	23 09 23 00	Direct Digital Control (DDC) System for HVAC
23 09 23 27	23 09 23 00a	Leak Detection Instruments
23 09 23 27	23 09 23 00b	Position Instruments
23 09 23 27	23 09 00 00	Speed Instruments
23 09 23 27	23 09 23 00c	Sequence of Operations for HVAC DDC
23 09 23 53	23 09 23 00	Direct Digital Control (DDC) System for HVAC
23 09 23 53	23 09 23 00a	Leak Detection Instruments
23 09 23 53	23 09 23 00b	Position Instruments
23 09 23 53	23 09 23 23	Pressure Instruments
23 09 23 53	23 09 00 00	Speed Instruments
23 09 23 53	23 09 23 00c	Sequence of Operations for HVAC DDC
23 09 43 00	23 09 00 00	Speed Instruments
23 11 00 00	22 12 23 26	Facility Fuel-Oil Piping
23 11 00 00	23 11 23 00	Facility Natural-Gas Piping
23 11 00 00	23 11 26 00	Facility Liquefied-Petroleum Gas Piping



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 11 23 00 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel pipe and fittings.
2. CSST and fittings.
3. Aluminum tubing, piping, and fittings.
4. Copper tubing and fittings.
5. PE pipe, tubing, and fittings.
6. Mechanical couplings.
7. Piping specialties.
8. Manual gas shutoff valve.
9. Manual gas shutoff ball valve.
10. Automatic gas shutoff valve.
11. Earthquake valve.
12. Pressure regulators.
13. Service meters.
14. Dielectric fittings.
15. Detectable warning tape.

B. Related Requirements:

1. Section 231126 "Facility Liquefied-Petroleum Gas Piping."

1.2 DEFINITIONS

- A. CSST: Corrugated stainless steel tubing.
- B. CWP: Cold working pressure.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. An example includes rooftop locations.
- D. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- E. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- F. PE: Polyethylene.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of specified product.



- B. Shop Drawings: Provide plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
 - 1. Shop Drawing Scale: **[1/4 inch per foot (1:50)]<Insert scale>** .
 - 2. Detail mounting, supports, and valve arrangements for **[service-meter assembly and]** pressure regulator assembly.
- C. Delegated Design Submittals: Comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of seismic restraints.
 - 2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.
- B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.
- C. Seismic Qualification Data: Submit certification that vaporizer, air mixer, storage container supports, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Welding Certificates: For piping.
- E. Field Quality Control Reports: For specified tests and inspections.
- F. Qualification Statements: For professional engineer.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For **[automatic gas shutoff valves][pressure regulators][and][service meters]** .

1.6 QUALITY ASSURANCE

- A. Steel Support Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators in accordance with the ASME Boiler and

Pressure Vessel Code.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping in accordance with requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.
- D. Protect stored PE pipes, tubing, and valves from direct sunlight.

1.8 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide purging and startup of natural-gas supply in accordance with requirements indicated:
 - 1. Notify **[Architect][Construction Manager][Owner]** no fewer than **[seven]<Insert number>** days in advance of proposed interruption of natural-gas service.
 - 2. Do not proceed with interruption of natural-gas service without **[Architect's][Construction Manager's][Owner's]** written permission.

1.9 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed and concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."
- C. Coordinate requirements for piping identification for natural-gas piping. Comply with requirements in Section 230553 "Identification of HVAC Piping and Equipment."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with **[NFPA 54][and][the International Fuel Gas Code]** for natural-gas distribution system, including materials, installation, and testing.
- B. Comply with requirements of authorities having jurisdiction.
- C. Comply with requirements of utility company supplying natural-gas.



D. Minimum Operating-Pressure Ratings:

1. Piping and Valves: [100 psig (690 kPa)]<Insert pressure> minimum.
2. Service Regulators: [65 psig (450 kPa)][100 psig (690 kPa)]<Insert pressure> minimum.
3. Service Meter: [5 psig (34.5 kPa)][10 psig (69 kPa)][20 psig (138 kPa)][65 psig (450 kPa)]<Insert value> .

E. Natural-Gas System Pressure within Buildings:

1. Single Pressure: [0.5 psig (3.45 kPa) or less][More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa)][More than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa)]<Insert pressure range> .
2. Two Pressure Ranges, Not More Than 2 psig (13.8 kPa): Primary pressure is more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa) and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.
3. Two Pressure Ranges, Not More Than 5 psig (34.5 kPa): Primary pressure is more than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa) and is reduced to secondary pressure of more than 0.5 psig (3.45 kPa), but not more than 2 psig (13.8 kPa).
4. Three Pressure Ranges: Primary pressure is more than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa) is reduced to secondary pressures of more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa) and is reduced again to pressures of 0.5 psig (3.45 kPa) or less.

F. Delegated Design: Design restraints and anchors for LPG piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Seismic Performance: Natural-gas piping system is to withstand the effects of earthquake motions determined in accordance with [ASCE/SEI 7]<Insert requirement> . See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the piping system will remain in place without separation of any parts from the device when subjected to the seismic forces specified [and the piping system will be fully operational after the seismic event] ."
2. Component Importance Factor: [1.5][1.0] .
3. Component Amplification Factor: <Insert requirement> .
4. Component Response Modification Factor: <Insert requirement> .

2.2 PIPE, TUBES, AND FITTINGS

A. Steel Pipe and Fittings:

1. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
2. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
3. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
4. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
5. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.

- c. Lapped Face: Unacceptable for underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum O-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
- 6. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
- B. CSST and Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[FlashShield Products; Gastite, a division of Titeflex Corp.]**
 - b. **[TracPipe CounterStrike; OmegaFlex, Inc.]**
 - c. **[Tru-Flex Metal Hose Corp]**
 - d. **[Ward Manufacturing LLC]**
 - e. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[FlashShield Products; Gastite, a division of Titeflex Corp.]**
 - b. **[TracPipe CounterStrike; OmegaFlex, Inc.]**
 - c. **[Tru-Flex Metal Hose Corp]**
 - d. **[Ward Manufacturing LLC]**
 - e. **<Insert manufacturer's name>**
 - 3. Source Limitation: Obtain CSST and fittings from single manufacturer.
 - 4. Standard: CSA/ANSI LC 1/CSA 6.26.
 - 5. Tubing: ASTM A240/A240M, corrugated, Series 300 stainless steel.
 - 6. Jacket: Electrically insulative and UV-resistant polymer with flame retardant.
 - a. Surface-Burning Characteristics: As determined by testing identical products in accordance with ASTM E84 by qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1) Flame-Spread Index: 25 or less.
 - 2) Smoke-Developed Index: 50 or less.
 - 7. Jacket with Fully Vent-Capable PE Sleeve: Include associated fittings suitable for locations requiring vented containment.
 - 8. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with CSST and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
 - 9. Striker Plates: Steel, designed to protect tubing from penetrations.
 - 10. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections are to comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
 - 11. Operating-Pressure Rating: **5 psig (34.5 kPa)**.

C. Aluminum Tubing, Piping, and Fittings:

1. Aluminum Tubing and Piping:
 - a. Standards:
 - 1) ASTM B210/B210M.
 - 2) ASTM B241/B241M.
 - b. Material: Aluminum Alloy 5456 is prohibited by NFPA 54.
2. Protective Coating: Factory-applied coating capable of resisting corrosion on tubing in contact with masonry, plaster, insulation, water, detergents, and sewerage.
3. Flare Fittings: ASME B16.26 and SAE J513.
 - a. Copper-alloy fittings.
 - b. Metal-to-metal compression seal without gasket.
 - c. Dryseal threads complying with ASME B1.20.3.

D. Copper Tubing and Fittings:

1. Drawn-Temper Copper Tube: **[ASTM B88, Type K (ASTM B88M, Type A)][and][ASTM B88, Type L (ASTM B88M, Type B)][ASTM B280, Type ACR][ASTM B837, Type G]** .
2. Annealed-Temper Copper Tube: **[ASTM B88, Type K (ASTM B88M, Type A)][and][ASTM B88, Type L (ASTM B88M, Type B)][ASTM B280, Type ACR][ASTM B837, Type G]** .
3. Coating: Factory-applied, extruded PE a minimum of **0.025 inch (0.64 mm)** thick. Continuously marked with size, specification information, manufacturing code, and footage every **2 ft. (610 mm)**.
4. Tin-Lined Copper Tube: ASTM B280, seamless, annealed, with interior tin-plated lining.
5. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
6. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
 - a. Gasket Material: ASME B16.20, metallic, flat, asbestos free, aluminum O-rings, and spiral-wound metal gaskets.
 - b. Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
7. Flare Fittings: Comply with ASME B16.26 and SAE J513.
 - a. Copper fittings with long nuts.
 - b. Metal-to-metal compression seal without gasket.
 - c. Dryseal threads complying with ASME B1.20.3.
8. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of **0.022 inch (0.56 mm)** thick.

E. PE Pipe, Tubing, and Fittings:

1. PE Pipe and Tubing: ASTM D2513, SDR 11.
2. PE Fittings: ASTM D2683, socket-fusion type or ASTM D3261, butt-fusion type.
3. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D2513, SDR 11; and steel pipe complying with ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
4. Anodeless Service-Line Risers: Factory fabricated and leak tested.
 - a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet.

- b. Casing: Steel pipe complying with ASTM A53/A53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. [**Vent casing aboveground.**]
 - c. Aboveground Portion: PE transition fitting.
 - d. Provide outlet threaded or flanged or suitable for welded connection.
 - e. Provide tracer wire connection.
 - f. Provide UV shield.
5. Transition Service-Line Risers: Factory fabricated and leak tested.
- a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet connected to steel pipe complying with ASTM A53/A53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
 - b. Provide outlet threaded or flanged or suitable for welded connection.
 - c. Provide bridging sleeve over mechanical coupling.
 - d. Provide factory-connected anode.
 - e. Provide tracer wire connection.
 - f. Provide UV shield.

2.3 MECHANICAL COUPLINGS

A. Mechanical Coupling - Plastic, NPS 1-1/2 (DN 40) and Smaller:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Continental Industries; brand of Hubbell Incorporated]**
 - b. **[Elster Perfection; Honeywell]**
 - c. **[Lyal; brand of Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Continental Industries; brand of Hubbell Incorporated]**
 - b. **[Elster Perfection; Honeywell]**
 - c. **[Lyal; brand of Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitation: Obtain couplings from single manufacturer.
- 4. Standard: ASTM D2513.
- 5. PE body.
- 6. Elastomeric seals.
- 7. Independent gripping collets.
- 8. Suitable for joining PE pipe to PE pipe.

B. Mechanical Coupling - Plastic, NPS 2 (DN 50) and Larger:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[Elster Perfection; Honeywell]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elster Perfection; Honeywell]**
 - b. **<Insert manufacturer's name>**
3. Source Limitation: Obtain couplings from single manufacturer.
4. Standard: ASTM D2513.
5. Stainless steel bolts, nuts, and washers.
6. Suitable for joining PE pipe to PE pipe.

C. Mechanical Coupling - Steel:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Smith-Blair, a Xylem brand.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Smith-Blair, a Xylem brand.]**
 - b. **<Insert manufacturer's name>**
3. Source Limitation: Obtain couplings from single manufacturer.
4. Flanges and Tube: **[Stainless steel][Steel]** with epoxy finish.
5. Seals: NBR.
6. Bolts, Washers, and Nuts: **[Stainless steel][Steel]** bolts, washers, and nuts.
7. Factory-installed anode for steel-body couplings installed underground.
8. Suitable for joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

2.4 PIPING SPECIALTIES

A. Appliance Flexible Connector:

1. Indoor, Fixed-Appliance Flexible Connectors: ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: ANSI Z21.75.
4. CSST with polymer coating.
5. Operating-Pressure Rating: **0.5 psig (3.45 kPa)**.
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: **72 inches (1830 mm)**.

B. Quick-Disconnect Device:

1. Standard: ANSI Z21.41/CSA 6.9.
2. Copper-alloy convenience outlet and matching plug connector.
3. Nitrile seals.
4. Hand operated with automatic shutoff when disconnected.
5. For indoor or outdoor applications.
6. Adjustable, retractable restraining cable.

C. Y-Pattern Strainer:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
3. Strainer Screen: **[40][60]** -mesh startup strainer, and perforated stainless steel basket with 50 percent free area.
4. CWP Rating: **125 psig (862 kPa)**.

D. Basket Strainer:

1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
3. Strainer Screen: **[40][60]** -mesh startup strainer, and perforated stainless steel basket with 50 percent free area.
4. CWP Rating: **125 psig (862 kPa)**.

E. T-Pattern Strainer:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: **[40][60]** -mesh startup strainer, and perforated stainless steel basket with 57 percent free area.
4. CWP Rating: **750 psig (5170 kPa)**.

F. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.5 Steel Pressure-Seal Fittings

A. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **<Insert manufacturer's name>**

2.6 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: AWS D10.12/D10.12M.

C. Brazing Filler Metals: AWS A5.8/A5.8M alloy with melting point greater than **1000 deg F (540 deg C)**. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.7 GAS VALVES

A. Manual Gas Shutoff Valve - Metallic:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[BrassCraft Manufacturing Co.; a Masco company]**
 - d. **[Jenkins Valves; a Crane Co. brand]**
 - e. **[Jomar Valve]**
 - f. **[Mueller Co.; Gas Products Division; a subsidiary of Mueller Gas Products Inc.]**
 - g. **[NIBCO INC.]**
 - h. **[Stockham; a Crane Co. brand]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[BrassCraft Manufacturing Co.; a Masco company]**
 - d. **[Jenkins Valves; a Crane Co. brand]**
 - e. **[Jomar Valve]**
 - f. **[Mueller Co.; Gas Products Division; a subsidiary of Mueller Gas Products Inc.]**
 - g. **[NIBCO INC.]**
 - h. **[Stockham; a Crane Co. brand]**
 - i. **<Insert manufacturer's name>**
3. Source Limitation: Obtain metallic manual gas shutoff valves from single manufacturer.
4. Description: Metallic ball valve or metallic plug valve of type indicated in schedules under Part 3.
5. Standards:
 - a. CSA/ANSI Z21.15/CSA 9.1.
 - b. ASME B16.33.
 - c. ASME B16.44.
6. System Pressure Rating: **[0.5 psig (3.45 kPa) or less][More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa)][More than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa)][More than 5 psig (34.5 kPa) but not more than 125 psig (862 kPa)]<Insert pressure>** .
7. Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service Mark: Initials "WOG" permanently marked on valve body.
9. End Connections:
 - a. Threaded Ends: ASME B1.20.1.
 - b. Dryseal Threads on Flare Ends: ASME B1.20.3.
 - c. Flanged Ends: ASME B16.5 for steel flanges.
10. Tamperproof locking feature.

B. Manual Gas Shutoff Ball Valve - PE:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Elster Perfection; Honeywell]**
 - b. **[Kerotest Manufacturing Corp]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elster Perfection; Honeywell]**
 - b. **[Kerotest Manufacturing Corp]**
 - c. **<Insert manufacturer's name>**
 3. Source Limitation: Obtain PE manual gas shutoff valves from single manufacturer.
 4. Standard: ASME B16.40.
 5. Body: PE.
 6. Ball: Polypropylene.
 7. Stem: Acetal.
 8. Seats and Seals: NBR.
 9. Ends: Plain or fusible to match piping.
 10. CWP Rating: **[80 psig (552 kPa)]<Insert pressure>** .
 11. Operating Temperature: **[Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C)]<Insert temperature range>** .
 12. Operator: Nut or flat head for key operation.
 13. Plastic valve extension.
 14. Tamperproof locking feature.
- C. Valve Box:
1. Cast-iron, two-section box.
 2. Top section with cover with "GAS" lettering.
 3. Bottom section with base to fit over valve and barrel a minimum of **5 inches (125 mm)** in diameter.
 4. Adjustable cast-iron extensions of length required for depth of bury.
 5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.
- D. Automatic Gas Shutoff Valve - Electrically Operated:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[American Gas Safety, LLC.]**
 - b. **[ASCO; an Emerson company]**
 - c. **[BASO Gas Products, LLC]**
 - d. **[Magnetrol Valve Corporation]**
 - e. **<Insert manufacturer's name>**

following:

- a. **[American Gas Safety, LLC.]**
 - b. **[ASCO; an Emerson company]**
 - c. **[BASO Gas Products, LLC]**
 - d. **[Magnatrol Valve Corporation]**
 - e. **<Insert manufacturer's name>**
3. Source Limitation: Obtain electrically operated automatic gas shutoff valves from single manufacturer.
 4. Description: Electrically operated automatic valve, solenoid type, used in natural-gas piping for automatic shutoff of service when interlocked with a hazard-condition initiating device.
 5. Standards:
 - a. CSA/ANSI Z21.21/CSA 6.5.
 - b. UL 429.
 - c. FM Global approved.
 6. Body: Brass or aluminum.
 7. Seats and Disc: NBR.
 8. Springs and Valve Trim: Stainless steel.
 9. Coil: Continuous-duty, molded coil, replaceable.
 10. Normally closed.
 11. Visual position indicator.
 12. Electrical Characteristics: **[120 V ac, 60 Hz][24 V ac, 60 Hz][24 V dc]<Insert value> .**

E. Earthquake Valve:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :**
 - a. **[Firefighter Gas Safety Products]**
 - b. **[Pacific Seismic Products, Inc]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Firefighter Gas Safety Products]**
 - b. **[Pacific Seismic Products, Inc]**
 - c. **<Insert manufacturer's name>**
3. Source Limitation: Obtain earthquake valves from same manufacturer.
4. Description: Seismically activated automatic gas shutoff valve.
5. Standard: ANSI/ASCE/SEI 25.
6. Maximum Operating Pressure: **[5 psig (34.5 kPa)][10 psig (69 kPa)][60 psig (414 kPa)]<Insert pressure> .**
7. Sight windows for visual indication of valve position.
8. Threaded end connections complying with ASME B1.20.1.
9. Threaded for valves **NPS 4 (DN 100)** and smaller; or flanged for valves **NPS 2 (DN 50)** and larger.
10. Wall-mounting bracket with bubble level indicator.

2.8 PRESSURE REGULATORS

A. Service Pressure Regulator:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Dresser Utility Solutions]**
 - b. **[Elster-American Meter]**
 - c. **[Fairview Ltd.]**
 - d. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - e. **[Marshall Excelsior Company]**
 - f. **[Maxitrol Company]**
 - g. **[RegO Products; a brand of Engineered Controls International, LLC]**
 - h. **[Richards Industrials]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dresser Utility Solutions]**
 - b. **[Elster-American Meter]**
 - c. **[Fairview Ltd.]**
 - d. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - e. **[Marshall Excelsior Company]**
 - f. **[Maxitrol Company]**
 - g. **[RegO Products; a brand of Engineered Controls International, LLC]**
 - h. **[Richards Industrials]**
 - i. **<Insert manufacturer's name>**
3. Source Limitation: Obtain service pressure regulators from single manufacturer.
4. Standards:
 - a. NFPA 54.
 - b. ANSI Z21.80/CSA 6.22.
5. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to regulator.
6. Pressure regulator is to maintain discharge pressure setting downstream and is to not exceed 150 percent of design discharge pressure at shutoff.
7. Maximum Inlet Pressure: **[100 psig (690 kPa)]<Insert pressure>** .
8. Maximum Outlet Pressure: **[2 psig (13.8 kPa)][5 psig (34.5 kPa)][10 psig (69 kPa)][20 psig (138 kPa)]<Insert pressure>** .
9. End Connections: Threaded for regulators **NPS 2 (DN 50)** and smaller; flanged for regulators **NPS 2-1/2 (DN 65)** and larger.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless steel screen in opening if not connected to vent piping.

B. Line Pressure Regulator:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [Cavagna North America]
- b. [Dormont; A Watts Water Technologies Company]
- c. [Dresser Utility Solutions]
- d. [Elster-American Meter]
- e. [Fischer; Emerson Electric Co., Automation Solutions]
- f. [Marshall Excelsior Company]
- g. [Maxitrol Company]
- h. [RegO Products; a brand of Engineered Controls International, LLC]
- i. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Cavagna North America]
- b. [Dormont; A Watts Water Technologies Company]
- c. [Dresser Utility Solutions]
- d. [Elster-American Meter]
- e. [Fischer; Emerson Electric Co., Automation Solutions]
- f. [Marshall Excelsior Company]
- g. [Maxitrol Company]
- h. [RegO Products; a brand of Engineered Controls International, LLC]
- i. <Insert manufacturer's name>

3. Source Limitation: Obtain line-pressure regulators from single manufacturer.

4. Standards:

- a. NFPA 54.
- b. CSA/ANSI Z21.80/CSA 6.22.

5. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to regulator.

6. Pressure regulator is to maintain discharge pressure setting downstream and is to not exceed 150 percent of design discharge pressure at shutoff.

7. Maximum Inlet Pressure: [2 psig (13.8 kPa)][5 psig (34.5 kPa)][10 psig (69 kPa)]<Insert pressure> .

8. Maximum Outlet Pressure: [2 psig (13.8 kPa)][5 psig (34.5 kPa)]<Insert pressure> .

9. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

10. Overpressure Protection Device: Factory mounted on pressure regulator.

11. Atmospheric Vent: Factory- or field-installed, stainless steel screen in opening if not connected to vent piping.

C. Appliance Pressure Regulator:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

- a. [Cavagna North America]
- b. [Dormont; A Watts Water Technologies Company]

- c. [Dresser Utility Solutions]
 - d. [Elster-American Meter]
 - e. [Fairview Ltd.]
 - f. [Marshall Excelsior Company]
 - g. [Maxitrol Company]
 - h. [RegO Products; a brand of Engineered Controls International, LLC]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Cavagna North America]
 - b. [Dormont; A Watts Water Technologies Company]
 - c. [Dresser Utility Solutions]
 - d. [Elster-American Meter]
 - e. [Fairview Ltd.]
 - f. [Marshall Excelsior Company]
 - g. [Maxitrol Company]
 - h. [RegO Products; a brand of Engineered Controls International, LLC]
 - i. <Insert manufacturer's name>
3. Source Limitation: Obtain appliance pressure regulators from single manufacturer.
4. Standards:
 - a. NFPA 54.
 - b. CSA/ANSI Z21.18/CSA 6.3.
5. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
6. Maximum Inlet Pressure: [1 psig (6.9 kPa)][2 psig (13.8 kPa)][5 psig (34.5 kPa)]<Insert pressure> .
7. Maximum Outlet Pressure: [1 psig (6.9 kPa)][2 psig (13.8 kPa)]<Insert pressure> .
8. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

2.9 SERVICE METERS

A. Diaphragm-Type Service Meter:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Dresser Utility Solutions]
 - b. [Elster-American Meter]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Dresser Utility Solutions]
 - b. [Elster-American Meter]

c. **<Insert manufacturer's name>**

3. Source Limitation: Obtain diaphragm-type service meters from single manufacturer.
4. Standard: **[ANSI B109.1][ANSI B109.2]** .
5. Case: Die-cast aluminum.
6. Connections: Steel threads.
7. Diaphragm: Synthetic fabric.
8. Diaphragm Support Bearings: Self-lubricating.
9. Compensation: Continuous temperature **[and pressure]** .
10. Meter Index: **[Cubic feet][Liters][Cubic feet and liters]** .
11. Meter Case and Index: Tamper resistant.
12. Remote meter reader compatible.
13. Maximum Inlet Pressure: **[100 psig (690 kPa)]<Insert pressure>** .
14. Pressure Loss: Maximum **[0.5 inch wg (124 Pa)][2.0 inch wg (498 Pa)]<Insert pressure differential>** .
15. Accuracy: Maximum plus or minus **[1.0]<Insert number>** percent.

B. Rotary-Type Service Meter:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Dresser Utility Solutions]**
 - b. **[Elster-American Meter]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dresser Utility Solutions]**
 - b. **[Elster-American Meter]**
 - c. **<Insert manufacturer's name>**
3. Source Limitation: Obtain rotary-type service meters from single manufacturer.
4. Standard: ANSI B109.3.
5. Case: Extruded aluminum.
6. Connection: Flange.
7. Impellers: Polished aluminum.
8. Rotor Bearings: Self-lubricating.
9. Compensation: Continuous temperature **[and pressure]** .
10. Meter Index: **[Cubic feet][Liters][Cubic feet and liters]** .
11. Tamper resistant.
12. Remote meter reader compatible.
13. Maximum Inlet Pressure: **[100 psig (690 kPa)]<Insert pressure>** .
14. Accuracy: Maximum plus or minus **[2.0]<Insert number>** percent.

C. Turbine Meter:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[Dresser Utility Solutions]**
 - b. **[Elster-American Meter]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dresser Utility Solutions]**
 - b. **[Elster-American Meter]**
 - c. **<Insert manufacturer's name>**
 3. Source Limitation: Obtain turbine meters from single manufacturer.
 4. Standard: ASME MFC.4M.
 5. Housing: Cast iron or welded steel.
 6. Connection Threads or Flanges: Steel.
 7. Turbine: Aluminum or plastic.
 8. Turbine Bearings: Self-lubricating.
 9. Compensation: Continuous temperature **[and pressure]** .
 10. Meter Index: **[Cubic feet][Liters][Cubic feet and liters]** .
 11. Tamper resistant.
 12. Remote meter reader compatible.
 13. Maximum Inlet Pressure: **[100 psig (690 kPa)]<Insert pressure>** .
 14. Accuracy: Maximum plus or minus **[2.0]<Insert number>** percent.
- D. Service-Meter Bar:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Mueller Co.; Gas Products Division; a subsidiary of Mueller Gas Products Inc.]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Mueller Co.; Gas Products Division; a subsidiary of Mueller Gas Products Inc.]**
 - c. **<Insert manufacturer's name>**
 3. Malleable- or cast-iron frame for supporting service meter.
 4. Include offset swivel pipes, meter nuts with O-ring seal, and factory- or field-installed dielectric unions.
 5. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.
- E. Service-Meter Bypass Fitting:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. **[A.Y. McDonald Mfg. Co.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **<Insert manufacturer's name>**
3. Ferrous, tee, pipe fitting with capped side inlet for temporary natural-gas supply.
4. Integral ball-check bypass valve.

2.10 DIELECTRIC FITTINGS

- A. Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Union:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[HART Industrial Unions, LLC]**
 - c. **[Jomar Valve]**
 - d. **[Matco-Norca]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[HART Industrial Unions, LLC]**
 - c. **[Jomar Valve]**
 - d. **[Matco-Norca]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**
 3. Standard: ASSE/IAMPO/ANSI/CAN 1079.
 4. Pressure Rating: **[125 psig (860 kPa) minimum at 180 deg F (82 deg C)][150 psig (1035 kPa) minimum at 180 deg F (82 deg C)][250 psig (1725 kPa) minimum at 180 deg F (82 deg C)]<Insert pressure rating at temperature>** .
 5. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flange:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

- a. **[Matco-Norca]**
 - b. **[WATTS; A Watts Water Technologies Company]**
 - c. **[Zurn Industries, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Matco-Norca]**
 - b. **[WATTS; A Watts Water Technologies Company]**
 - c. **[Zurn Industries, LLC]**
 - d. **<Insert manufacturer's name>**
3. Standard: ASSE 1079.
4. Factory-fabricated, bolted, companion-flange assembly.
5. Pressure Rating: **[125 psig (860 kPa) minimum at 180 deg F (82 deg C)][150 psig (1035 kPa) minimum at 180 deg F (82 deg C)][175 psig (1200 kPa) minimum at 180 deg F (82 deg C)][300 psig (2070 kPa) minimum at 180 deg F (82 deg C)]<Insert pressure at temperature>** .
6. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric-Flange Insulating Kit:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
- a. **[Advance Products & Systems, LLC]**
 - b. **[CALPICO, Inc.]**
 - c. **[GPT Industries, LLC.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Advance Products & Systems, LLC]**
 - b. **[CALPICO, Inc.]**
 - c. **[GPT Industries, LLC.]**
 - d. **<Insert manufacturer's name>**
3. Nonconducting materials for field assembly of companion flanges.
4. Pressure Rating: **[150 psig (1035 kPa)]<Insert pressure>** .
5. Gasket: Neoprene or phenolic.
6. Bolt Sleeves: Phenolic or polyethylene.
7. Washers: Phenolic with steel backing washers.

2.11 DETECTABLE WARNING TAPE

- A. Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of **6 inches (150 mm)** wide and **4 mils (0.1 mm)** thick, continuously inscribed with a description and rated pressure of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to **30 inches (750 mm)** deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping in accordance with **[NFPA 54,][the International Fuel Gas Code,]** and authorities having jurisdiction to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with **[NFPA 54,][the International Fuel Gas Code,]** and authorities having jurisdiction requirements for preventing accidental ignition.

3.4 INSTALLATION OF PIPE, TUBES, AND FITTINGS

- A. Outdoor Piping: Comply with **[NFPA 54,][the International Fuel Gas Code,]** and authorities having jurisdiction requirements for installation and purging of natural-gas piping.
 - 1. Install underground, natural-gas piping buried at least **[18 inches (460 mm)]<Insert value>** below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.
 - a. If natural-gas piping is installed less than **12 inches (300 mm)** below finished grade, install it in containment conduit.
 - 2. Install underground, PE, natural-gas piping in accordance with ASTM D2774.
 - 3. Steel Piping with Protective Coating:
 - a. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - b. Repair damage to PE coating on pipe as recommended in writing by protective coating

- manufacturer.
 - c. Replace pipe having damaged PE coating with new pipe.
 - 4. Copper Tubing with Protective Coating:
 - a. Apply joint cover kits over tubing to cover, seal, and protect joints.
 - b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - 5. Install fittings for changes in direction and branch connections.
 - 6. Joints for connection to inlets and outlets on regulators, and valves may be flanged or threaded to match the equipment.
 - 7. Install pressure gauge [**downstream**][**upstream and downstream**] from each service regulator. Pressure gauges are specified in Section 230500 "Common Work Results for HVAC."
- B. Indoor Piping: Comply with [**NFPA 54,**][**the International Fuel Gas Code,**] and authorities having jurisdiction requirements for installation and purging of natural-gas piping.
- 1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
 - 2. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
 - 3. Install piping in concealed locations unless otherwise indicated on Drawings. Piping in equipment rooms and service areas may be installed exposed. Piping is not to be installed in inaccessible locations.
 - a. Conceal piping in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
 - b. Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit in accordance with [**NFPA 54,**][**the International Fuel Gas Code,**] and authorities having jurisdiction. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
 - 1) Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
 - a) Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
 - 2) In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of **1-1/2 inches (38 mm)** of concrete. Piping may not be in physical contact with other metallic structures, such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
 - 3) In Floor Channels: Channels must have cover and be open to space above cover for ventilation.
 - 4) In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - a) Exception: Tubing passing through partitions or walls does not require striker barriers.
 - 5) Prohibited Locations:



- a) Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - b) Do not install natural-gas piping in return-air plenums.
 - c) Do not install natural-gas piping in solid walls or partitions.
- 6) Under the Building: Install in vented containment conduit or CSST with integral vented sleeve and associated fittings.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise on Drawings.
5. Locate valves for easy access from a standing position. Do not locate valves within return air plenums.
6. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
7. Install piping free of sags and bends.
8. Install fittings for changes in direction and branch connections.
9. Comply with requirements in Sections specifying gas-fired appliances and equipment, and verify final appliance and equipment locations for roughing-in requirements.
10. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where readily accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - a. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of three pipe diameters, but not less than **3 inches (75 mm)** long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
 - b. Install sediment trap on both sides of regulators for gas reduction to **2 psig (13.8 kPa)** with valve and cap.
11. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors, and terminate with weatherproof vent cap.
12. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
13. Connect branch piping from top or side of horizontal piping.
14. Install unions in pipes **NPS 2 (DN 50)** and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
15. Do not use natural-gas piping as grounding electrode.
16. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve. Remove and replace startup strainer with new strainer prior to final acceptance tests.
17. Install pressure gauge [**downstream**][**upstream and downstream**] from each line regulator. Pressure gauges are specified in Section 230500 "Common Work Results for HVAC."
18. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."
19. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common Work Results for HVAC."
20. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

3.5 INSTALLATION OF SERVICE METERS

- A. Install service-meter assemblies aboveground [, **on concrete bases**] .
- B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.

- C. Install strainer on inlet of service-pressure regulator and meter set.
- D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.
- E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.
- F. Install service meters downstream from pressure regulators.
- G. Install metal bollards to protect meter assemblies. Comply with requirements in Section 055000 "Metal Fabrications" for pipe bollards.

3.6 INSTALLATION OF PRESSURE REGULATORS

- A. Ensure the gas supply is completely shut off at the main valve and that the line is fully depressurized.
- B. Remove any shipping plugs from the inlet, outlet, and vent connections. Ensure the pipe interior and regulator are free of dirt, debris, and contaminants.
- C. Apply pipe joint sealant or Teflon tape rated for gas use to the male threads of the pipe. Avoid getting sealant on the female threads or inside the regulator.
- D. Mount the regulator in the correct orientation, aligning the flow arrow on the body with the direction of gas flow. The piping must be properly aligned and supported to avoid stressing the regulator.
- E. If the pressure regulator is installed inside of a building, install a dedicated vent line directly from the regulator to the outdoors. The vent terminal must be insect resistant and rain resistant. The regulator should be at least **3 ft. (914 mm)** horizontally from any building opening below the vent opening, and positioned so that gas can disperse freely.

3.7 INSTALLATION OF GAS VALVES

- A. Install manual gas shutoff valve for each gas appliance ahead of CSST, aluminum, or copper connector.
- B. Install underground valves with valve boxes.
- C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- D. Install earthquake valves aboveground outside buildings according to listing.
- E. Install anode for metallic valves in underground PE piping.
- F. Do not install valves in return-air plenums.

3.8 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints in accordance with AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, and then use wrench. Do not overtighten.

H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join in accordance with ASTM D2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.9 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- C. Install hangers for **[steel piping][and][copper tubing]**, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Install hangers for corrugated stainless steel tubing, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Support horizontal piping within **[12 inches (300 mm)]<Insert dimension>** of each fitting.
- F. Support vertical runs of **[steel piping][and][copper tubing]** to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

- G. Support vertical runs of corrugated stainless steel tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.10 PIPING CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous, and bonded to gas-appliance equipment grounding conductor of the circuit powering the appliance in accordance with NFPA 70.
- C. Install piping adjacent to appliances to allow space for service and maintenance of appliances.
- D. Connect piping to appliances using manual gas-shutoff valves and unions. Install valve within **72 inches (1800 mm)** of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

3.11 INSTALLATION OF LABELING AND IDENTIFICATION

- A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, **12 inches (300 mm)** below finished grade, except **6 inches (150 mm)** below subgrade under pavements and slabs.
- C. Label and identify gas piping and pressure outside a multitenant building by tenant.

3.12 CONCRETE BASES

- A. Anchor equipment to concrete base [.] **in accordance with seismic codes of Project. See Section 230548 "Vibration and Seismic Controls for HVAC."**
- B. Construct concrete bases of dimensions indicated, but not less than **4 inches (100 mm)** larger in both directions than supported unit.
- C. Install dowel rods to connect concrete base to concrete floor. Install dowel rods on [**18-inch (450-mm)**]**<Insert dimension>** centers around the full perimeter of the base.
- D. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
- E. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
- F. Install anchor bolts to elevations required for proper attachment to supported equipment.
- G. Use [**3000 psig (20.7 MPa)**]**<Insert value>**, 28-day, compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete."

3.13 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Comply with **[NFPA 54,][the International Fuel Gas Code,]** and authorities having jurisdiction requirements for testing, inspection, and purging of natural-gas installation.
 - 2. Natural-gas installation will be considered defective if it does not pass tests and inspections. Defective products are to be replaced. Retest installation after defective products have been replaced for code compliance.
- B. Prepare test and inspection reports.

3.14 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.15 OUTDOOR NATURAL-GAS PIPING SCHEDULE

- A. Underground Natural-Gas Piping: To be one of the following:
 - 1. PE Pipe, Tubing and Fittings: Terminate service-line risers with tracer wire in an accessible location.
 - 2. Steel Pipe: With wrought-steel welding fittings or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
 - 3. Drawn-Temper Copper Tube: With copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
 - 4. Annealed-Temper Copper Tube: With copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
 - 5. Containment Conduit: In accordance with **[NFPA 54,][the International Fuel Gas Code,]** and authorities having jurisdiction.
 - 6. CSST and Fittings: With integral vented sleeve terminated in an accessible location.
- B. Aboveground Natural-Gas Piping: To be one of the following:
 - 1. CSST and fittings.
 - 2. Steel pipe with malleable-iron threaded fittings.
 - 3. Steel pipe with wrought-steel welded fittings.
 - 4. Drawn-Temper Copper Tube: With wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
 - 5. Annealed-Temper Copper Tube: With wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.

3.16 INDOOR NATURAL-GAS PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 kPa)

- A. Aboveground Branch Piping NPS 1 (DN 25) and Smaller: To be one of the following:
 - 1. CSST and fittings.
 - 2. Tin-Lined Copper Tube: With flared joints and fittings.
 - 3. Annealed-Temper Copper Tube: With wrought-copper fittings and **[brazed][flared]** joints.

4. Aluminum Tube: With flared fittings and joints.
 5. Steel Pipe: With malleable-iron threaded fittings.
- B. Aboveground Distribution Piping: To be one of the following:
1. Steel pipe with malleable-iron threaded fittings.
 2. Steel pipe with wrought-steel welding fittings.
 3. Drawn-Temper Copper Tube: With wrought-copper fittings and brazed joints.
- C. Underground Below-Building Piping: To be one of the following:
1. Steel pipe with malleable-iron threaded fittings.
 2. Steel pipe with wrought-steel welding fittings.
 3. Containment Conduit: In accordance with **[NFPA 54,][the International Fuel Gas Code,]** and authorities having jurisdiction.
 4. Containment Conduit Vent Piping: In accordance with **[NFPA 54,][the International Fuel Gas Code,]** and authorities having jurisdiction.
- 3.17 INDOOR NATURAL-GAS PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG (3.45 kPa) AND LESS THAN 5 PSIG (34.5 kPa)
- A. Aboveground Branch Piping NPS 1 (DN 25) and Smaller: To be one of the following:
1. CSST and fittings.
 2. Tin-Lined Copper Tube: With flared joints and fittings.
 3. Annealed-Temper Copper Tube: With wrought-copper fittings and **[brazed][flared]** joints.
 4. Aluminum Tubing and Piping: With flared fittings and joints.
 5. Steel Pipe: With malleable-iron threaded fittings.
- B. Aboveground Distribution Piping: To be one of the following:
1. Steel pipe with malleable-iron threaded fittings.
 2. Steel pipe with wrought-steel welding fittings.
 3. Drawn-Temper Copper Tube: With wrought-copper fittings and brazed joints.
- C. Underground Below-Building Piping: To be one of the following:
1. Steel pipe with malleable-iron threaded fittings.
 2. Steel pipe with wrought-steel welding fittings.
 3. Containment Conduit: In accordance with **[NFPA 54,][the International Fuel Gas Code,]** and authorities having jurisdiction.
 4. Containment Conduit Vent Piping: In accordance with **[NFPA 54,][the International Fuel Gas Code,]** and authorities having jurisdiction.
- 3.18 INDOOR NATURAL-GAS PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 5 PSIG (34.5 kPa)
- A. Aboveground Piping: Maximum operating pressure more than **[5 psig (34.5 kPa)]<Insert pressure>** .
- B. Aboveground, Branch Piping:
1. Steel Pipe: With wrought-steel welding fittings.

- C. Aboveground Distribution Piping: To be one of the following:
 - 1. Steel Pipe: With wrought-steel welding fittings.
 - 2. Drawn-Temper Copper Tube: With wrought-copper fittings and brazed joints.
- D. Underground Below-Building Piping: To be one of the following:
 - 1. Steel pipe with malleable-iron threaded fittings.
 - 2. Steel pipe with wrought-steel welding fittings.
 - 3. Containment Conduit: In accordance with **[NFPA 54,][the International Fuel Gas Code,]** and authorities having jurisdiction.
 - 4. Containment Conduit Vent Piping: In accordance with **[NFPA 54,][the International Fuel Gas Code,]** and authorities having jurisdiction.

3.19 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.
- B. Underground:
 - 1. Manual gas shutoff ball valve - PE.
 - 2. Manual gas shutoff valve - metallic.

3.20 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Aboveground Natural-Gas Piping: Manual gas shutoff valve - metallic.

END OF SECTION 23 11 23 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 11 23 00	21 05 00 00	Common Work Results for Fire Suppression
23 11 23 00	22 05 00 00	Common Work Results for Plumbing
23 11 23 00	23 05 00 00	Common Work Results for HVAC
23 11 23 00	22 12 23 26	Facility Fuel-Oil Piping
23 11 23 00	23 11 26 00	Facility Liquefied-Petroleum Gas Piping
23 11 23 00	33 11 13 00a	Potable Water Supply Wells



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 11 26 00 - FACILITY LIQUEFIED-PETROLEUM GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel pipe and fittings.
2. CSST and fittings.
3. Aluminum tubing, piping, and fittings.
4. Copper tubing and fittings.
5. PE pipe, tubing, and fittings.
6. Polyamide pipe, tubing, and fittings.
7. Mechanical couplings.
8. Piping specialties.
9. Manual gas shutoff valve.
10. Manual gas shutoff ball valve.
11. Valve boxes.
12. Automatic gas shutoff valve.
13. Earthquake valve.
14. Pressure regulators.
15. Service meters.
16. Dielectric fittings.
17. Storage containers.
18. Transport truck unloading facility.
19. Vaporizers.
20. Detectable warning tape.

B. Related Requirements:

1. Section 231123 Facility Natural-Gas Piping.

1.2 DEFINITIONS

- A. CSST: Corrugated stainless steel tubing.
- B. CWP: Cold working pressure.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- E. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- F. LPG: Liquefied-petroleum gas.



- G. PE: Polyethylene.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of specified product.
- B. Shop Drawings: Provide plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
 - 1. Shop Drawings Scale: **[1/4 inch per foot (1:50)]<Insert scale>** .
 - 2. Detail mounting, supports, and valve arrangements for [**service meter assembly and**] pressure regulator assembly.
- C. Delegated Design Submittals: Comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of seismic restraints.
 - 2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and details, drawn to scale, on which LPG piping is indicated and coordinated with other installations, using input from installers of the items involved.
- B. Site Survey: Plans, drawn to scale, on which LPG piping is shown and coordinated with other services and utilities.
- C. Seismic Qualification Data: Submit certification that vaporizer, air mixer, storage container supports, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Welding Certificates: For piping.
- E. Field Quality Control Reports: For specified tests and inspections.
- F. Qualification Statements: For professional engineer.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For **[automatic gas shutoff valves][pressure regulators][and][service meters]** .

1.6 QUALITY ASSURANCE

- A. Steel Support Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators in accordance with the ASME Boiler and Pressure Vessel Code.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing LPG piping in accordance with requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store and handle pipes and tubes with factory-applied protective coating to avoid damaging coating, and protect from direct sunlight.
- D. Protect stored PE pipes, tubing, and valves from direct sunlight.

1.8 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. Interruption of Existing LPG Service: Do not interrupt LPG service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of LPG supply in accordance with requirements indicated:
 - 1. Notify **[Architect][Construction Manager][Owner]** no fewer than **[seven]<Insert number>** days in advance of proposed interruption of LPG service.
 - 2. Do not proceed with interruption of LPG service without **[Architect's][Construction Manager's][Owner's]** written permission.

1.9 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."
- C. Coordinate requirements for piping identification for natural-gas piping. Comply with requirements in Section 230553 "Identification of HVAC Piping and Equipment."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with requirements of **[NFPA 58][and][the International Fuel Gas Code]** for LPG distribution

system, including materials, installation, and testing.

- B. Comply with requirements of authorities having jurisdiction.
- C. Comply with requirements of utility company supplying LPG.
- D. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: **[125 psig (862 kPa)]<Insert pressure>** minimum.
 - 2. Service Regulators: **[65 psig (450 kPa)][100 psig (690 kPa)]<Insert pressure>** minimum.
 - 3. Service Meter: **[5 psig (34.5 kPa)][10 psig (69 kPa)][20 psig (138 kPa)][65 psig (450 kPa)]<Insert pressure>** .
- E. LPG System Pressure within Buildings:
 - 1. Single Pressure: **[0.5 psig (3.45 kPa) or less][More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa)][More than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa)]<Insert pressure range>** .
 - 2. Two Pressure Ranges, Not More Than 2 psig (13.8 kPa): Primary pressure is more than **0.5 psig (3.45 kPa)** but not more than **2 psig (13.8 kPa)** and is reduced to secondary pressure of **0.5 psig (3.45 kPa)** or less.
 - 3. Two Pressure Ranges, Not More Than 5 psig (34.5 kPa): Primary pressure is more than **2 psig (13.8 kPa)** but not more than **5 psig (34.5 kPa)** and is reduced to secondary pressure of more than **0.5 psig (3.45 kPa)** but not more than **2 psig (13.8 kPa)**.
 - 4. Three Pressure Ranges: Primary pressure is more than **2 psig (13.8 kPa)** but not more than **5 psig (34.5 kPa)**, is reduced to secondary pressures of more than **0.5 psig (3.45 kPa)** but not more than **2 psig (13.8 kPa)** and is reduced again to pressures of **0.5 psig (3.45 kPa)** or less.
- F. Delegated Design: Design restraints and anchors for LPG piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- H. Seismic Performance: LPG piping system, vaporizers, and storage container supports are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>** . See Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
 - 1. The term "withstand" means "the piping/unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified [**and the piping system will be fully operational after the seismic event**] ."
 - 2. Component Importance Factor: **[1.5][1.0]** .
 - 3. Component Amplification Factor: **<Insert requirement>**
 - 4. Component Response Modification Factor: **<Insert requirement>**

2.2 PIPE, TUBING, AND FITTINGS

- A. Steel Pipe and Fittings:
 - 1. Steel Pipe: ASTM A53/A53M black steel, Schedules 40 and 80, Type E or S, Grade B.
 - 2. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 3. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
 - 4. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and

- threaded ends.
5. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Lapped Face: Unacceptable for underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum O-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground, and stainless steel underground.
 6. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
- B. CSST and Fittings:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[FlashShield Products; Gastite, a division of Titeflex Corp.]**
 - b. **[TracPipe CounterStrike; OmegaFlex, Inc.]**
 - c. **[Tru-Flex Metal Hose Corp]**
 - d. **[Ward Manufacturing LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[FlashShield Products; Gastite, a division of Titeflex Corp.]**
 - b. **[TracPipe CounterStrike; OmegaFlex, Inc.]**
 - c. **[Tru-Flex Metal Hose Corp]**
 - d. **[Ward Manufacturing LLC]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitation: Obtain CSST and fittings from single manufacturer.
 4. Standard: CSA/ANSI LC 1/CSA 6.26.
 5. Tubing: ASTM A240/A240M, corrugated, Series 300 stainless steel.
 6. Jacket: Electrically Insulative and UV-Resistant Polymer with Flame Retardant.
 - a. Surface-Burning Characteristics: As determined by testing identical products in accordance with ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1) Flame-Spread Index: 25 or less.
 - 2) Smoke-Developed Index: 50 or less.
 7. Jacket with Fully Vent-Capable PE Sleeve: Include associated fittings suitable for locations requiring vented containment.
 8. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with CSST and suitable for metal-to-metal seal without gaskets. Include brazing socket or threaded ends

- complying with ASME B1.20.1.
- 9. Striker Plates: Steel, designed to protect tubing from penetrations.
- 10. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections are to comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
- 11. Operating-Pressure Rating: **5 psig (34.5 kPa)**.

C. Aluminum Tubing, Piping, and Fittings:

- 1. Aluminum Tubing:
 - a. Standards:
 - 1) ASTM B210/B210M.
 - 2) ASTM B241/B241M.
 - b. Material: Aluminum Alloy 5456 is prohibited per NFPA 54.
- 2. Protective Coating: Factory-applied coating capable of resisting corrosion on tubing in contact with masonry, plaster, insulation, water, detergents, and sewerage.
- 3. Flare Fittings: Comply with ASME B16.26 and SAE J513.
 - a. Copper-alloy fittings.
 - b. Metal-to-metal compression seal without gasket.
 - c. Dryseal threads are to comply with ASME B1.20.3.

D. Copper Tubing and Fittings:

- 1. Drawn-Temper Copper Tube: **[ASTM B88, Type K (ASTM B88M, Type A)][and][ASTM B88, Type L (ASTM B88M, Type B)][ASTM B280, Type ACR][ASTM B837, Type G]**.
- 2. Annealed-Temper Copper Tube: **[ASTM B88, Type K (ASTM B88M, Type A)][and][ASTM B88, Type L (ASTM B88M, Type B)][ASTM B280, Type ACR][ASTM B837, Type G]**.
- 3. Coating: Factory-applied, extruded PE a minimum of **0.025 inch (0.64 mm)** thick. Continuously marked with size, specification information, manufacturing code, and footage every **2 ft. (610 mm)**.
- 4. Tin-Lined Copper Tube: ASTM B280, seamless, annealed, with interior tin-plated lining.
- 5. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
- 6. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
 - a. Gasket Material: ASME B16.20, metallic, flat, asbestos-free, aluminum o-rings and spiral-wound metal gaskets.
 - b. Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
- 7. Flare Fittings: ASME B16.26 and SAE J513.
 - a. Copper fittings with long nuts.
 - b. Metal-to-metal compression seal without gasket.
 - c. Dryseal threads complying with ASME B1.20.3.
- 8. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of **0.022 inch (0.56 mm)** thick.

E. PE Pipe, Tubing, and Fittings:

- 1. PE Pipe and Tubing: ASTM D2513, SDR 11.
- 2. PE Fittings: ASTM D2683, socket-fusion type or ASTM D3261, butt-fusion type.

3. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D2513, SDR 11, and steel pipe complying with ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
4. Anodeless Service-Line Riser: Factory fabricated and leak tested.
 - a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet.
 - b. Casing: Steel pipe complying with ASTM A53/A53M, Schedule 40, black steel, Type E or S, Grade B with corrosion-protective coating covering. [**Vent casing aboveground.**]
 - c. Aboveground Portion: PE transition fitting.
 - d. Provide outlet threaded or flanged or suitable for welded connection.
 - e. Provide tracer wire connection.
 - f. Provide UV shield.
5. Transition Service-Line Riser: Factory fabricated and leak tested.
 - a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet connected to steel pipe complying with ASTM A53/A53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
 - b. Provide outlet threaded or flanged or suitable for welded connection.
 - c. Provide bridging sleeve over mechanical coupling.
 - d. Provide factory-connected anode.
 - e. Provide tracer wire connection.
 - f. Provide UV shield.

F. Polyamide Pipe, Tubing, and Fittings: ASTM F2945.

2.3 MECHANICAL COUPLINGS

A. Mechanical Coupling - Plastic, NPS 1-1/2 (DN 40) and Smaller:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Continental Industries; brand of Hubbell Incorporated]**
 - b. **[Elster Perfection; Honeywell]**
 - c. **[Lyal; brand of Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Continental Industries; brand of Hubbell Incorporated]**
 - b. **[Elster Perfection; Honeywell]**
 - c. **[Lyal; brand of Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
3. Source Limitation: Obtain couplings from single manufacturer.
4. Standard: ASTM D2513.
5. PE body.
6. Elastomeric seals.
7. Independent gripping collets.
8. Couplings are to be suitable for joining PE pipe to PE pipe.

B. Mechanical Coupling - Plastic, NPS 2 (DN 50) and Larger:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Elster Perfection; Honeywell]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elster Perfection; Honeywell]**
 - b. **<Insert manufacturer's name>**
3. Source Limitation: Obtain couplings from single manufacturer.
4. Standard: ASTM D2513.
5. Stainless steel bolts, nuts, and washers.
6. Couplings are to be suitable for joining PE pipe to PE pipe.

C. Mechanical Coupling - Steel:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Smith-Blair, a Xylem brand.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Smith-Blair, a Xylem brand.]**
 - b. **<Insert manufacturer's name>**
3. Source Limitation: Obtain couplings from single manufacturer.
4. Flanges and Tube: **[Stainless steel][Steel]** with epoxy finish.
5. Seals: NBR.
6. Bolts, Washers, and Nuts: **[Stainless steel][Steel]** bolts, washers, and nuts.
7. Factory-installed anode for steel-body couplings installed underground.
8. Suitable for joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

2.4 PIPING SPECIALTIES

A. Flexible Piping Joint:

1. Approved for LPG service.
2. Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
3. Minimum working pressure of **250 psig (1723 kPa)** and **250 deg F (121 deg C)** operating temperature.

4. Flanged- or threaded-end connections to match equipment connected and to be capable of minimum **3/4-inch (20-mm)** misalignment.
 5. Maximum **36-inch (914-mm)** length for liquid LPG lines.
- B. Appliance Flexible Connector:
1. Indoor, Fixed-Appliance Flexible Connectors: CSA/ANSI Z21.24.
 2. Indoor, Movable-Appliance Flexible Connectors: CSA/ANSI Z21.69.
 3. Outdoor, Appliance Flexible Connectors: CSA/ANSI Z21.75.
 4. CSST with polymer coating.
 5. Operating-Pressure Rating: **0.5 psig (3.45 kPa)**.
 6. End Fittings: Zinc-coated steel.
 7. Threaded Ends: ASME B1.20.1.
 8. Maximum Length: **72 inches (1830 mm)**.
- C. Quick-Disconnect Device:
1. Standard: CSA/ANSI Z21.41/CSA 6.9.
 2. Copper-alloy convenience outlet and matching plug connector.
 3. Nitrile seals.
 4. Hand operated with automatic shutoff when disconnected.
 5. For indoor or outdoor applications.
 6. Adjustable, retractable restraining cable.
- D. Y-Pattern Strainer:
1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
 2. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
 3. Strainer Screen: **[40][60]** -mesh startup strainer and perforated stainless steel basket with 50 percent free area.
 4. CWP Rating: **125 psig (862 kPa)**.
- E. Basket Strainer:
1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
 2. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
 3. Strainer Screen: **[40][60]** -mesh startup strainer and perforated stainless steel basket with 50 percent free area.
 4. CWP Rating: **125 psig (862 kPa)**.
- F. T-Pattern Strainer:
1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
 2. End Connections: Grooved ends.
 3. Strainer Screen: **[40][60]** -mesh startup strainer and perforated stainless steel basket with 57 percent free area.
 4. CWP Rating: **750 psig (5170 kPa)**.
- G. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.5 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for LPG.
- B. Welding Filler Metals: AWS D10.12/D10.12M.
- C. Brazing Filler Metals: AWS A5.8/A5.8M alloy with melting point greater than **1000 deg F (540 deg C)**. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.6 GAS VALVES

A. Manual Gas Shutoff Valve - Metallic:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[BrassCraft Manufacturing Co.; a Masco company]**
 - d. **[Jenkins Valves; a Crane Co. brand]**
 - e. **[Jomar Valve]**
 - f. **[Mueller Co.; Gas Products Division; a subsidiary of Mueller Gas Products Inc.]**
 - g. **[NIBCO INC.]**
 - h. **[Stockham; a Crane Co. brand]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[BrassCraft Manufacturing Co.; a Masco company]**
 - d. **[Jenkins Valves; a Crane Co. brand]**
 - e. **[Jomar Valve]**
 - f. **[Mueller Co.; Gas Products Division; a subsidiary of Mueller Gas Products Inc.]**
 - g. **[NIBCO INC.]**
 - h. **[Stockham; a Crane Co. brand]**
 - i. **<Insert manufacturer's name>**
3. Source Limitation: Obtain metallic manual gas shutoff valves from single manufacturer.
4. Description: Metallic ball valve or metallic plug valve of type indicated in schedules under Part 3.
5. Standards:
 - a. CSA/ANSI Z21.15/CSA 9.1.
 - b. ASME B16.33.
 - c. ASME B16.44.
6. System Pressure Rating: **[0.5 psig (3.45 kPa) or less][More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa)][More than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa)][More than 5 psig (34.5 kPa) but not more than 125 psig (862 kPa)]<Insert pressure>** .
7. Listed and labeled by an NRTL acceptable to authorities having jurisdiction.

8. Service Mark: Initials "WOG" permanently marked on valve body.
 9. End Connections:
 - a. Threaded Ends: ASME B1.20.1.
 - b. Dryseal Threads on Flare Ends: ASME B1.20.3.
 - c. Flanged Ends: ASME B16.5 for steel flanges.
 10. Tamperproof locking feature.
- B. Manual Gas Shutoff Ball Valve - PE:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Elster Perfection; Honeywell]**
 - b. **[Kerotest Manufacturing Corp]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elster Perfection; Honeywell]**
 - b. **[Kerotest Manufacturing Corp]**
 - c. **<Insert manufacturer's name>**
 3. Source Limitation: Obtain PE manual gas shutoff valves from single manufacturer.
 4. Standard: ASME B16.40.
 5. Body: PE.
 6. Ball: Polypropylene.
 7. Stem: Acetal.
 8. Seats and Seals: NBR.
 9. Ends: Plain or fusible to match piping.
 10. CWP Rating: **[80 psig (552 kPa)]<Insert pressure>** .
 11. Operating Temperature: **[Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C)]<Insert temperature range>** .
 12. Operator: Nut or flat head for key operation.
 13. Plastic valve extension.
 14. Tamperproof locking feature.
- C. Valve Boxes:
1. Cast-iron, two-section box.
 2. Top section with cover with "GAS" lettering.
 3. Bottom section with base to fit over valve and barrel a minimum of **5 inches (125 mm)** in diameter.
 4. Adjustable cast-iron extensions of length required for depth of bury.
 5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head and with stem of length required to operate valve.
- D. Automatic Gas Shutoff Valve - Hydrostatic Relief:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following] :

- a. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - b. **[Marshall Excelsior Company]**
 - c. **[RegO Products; a brand of Engineered Controls International, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - b. **[Marshall Excelsior Company]**
 - c. **[RegO Products; a brand of Engineered Controls International, LLC]**
 - d. **<Insert manufacturer's name>**
3. Source Limitation: Obtain hydrostatic relief valves from single manufacturer.
4. Standard: NFPA 58.
5. Operating Pressure: **[350 psig (2413 kPa)]<Insert pressure>** .
6. Body: Brass.
7. Spring: Stainless steel.
8. Disc and Seat: NBR.
9. Brass body and stainless steel, spring-operated valve with resilient rubber disc seat and protective cap.
10. Factory set and tested.
11. Valve is to automatically reseal after relieving pressure.

E. Automatic Gas Shutoff Valve - Electrically Operated:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :**
- a. **[American Gas Safety, LLC.]**
 - b. **[ASCO; an Emerson company]**
 - c. **[BASO Gas Products, LLC]**
 - d. **[Magnetrol Valve Corporation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[American Gas Safety, LLC.]**
 - b. **[ASCO; an Emerson company]**
 - c. **[BASO Gas Products, LLC]**
 - d. **[Magnetrol Valve Corporation]**
 - e. **<Insert manufacturer's name>**
3. Source Limitation: Obtain electrically operated automatic gas shutoff valves from single manufacturer.
4. Description: Electrically operated automatic valve, solenoid type, used in LPG piping for automatic shutoff of service when interlocked with a hazard-condition initiating device.

5. Standards:
 - a. CSA/ANSI Z21.21/CSA 6.5.
 - b. UL 429.
 - c. FM Global approved.
6. Body: Brass or aluminum.
7. Seats and Disc: NBR.
8. Springs and Valve Trim: Stainless steel.
9. Coil: Continuous-duty, molded enclosure, replaceable.
10. Normally closed.
11. Visual position indicator.
12. Electrical Characteristics: **[120 V ac, 60 Hz][24 V ac, 60 Hz][24 V dc]<Insert value>** .

F. Earthquake Valve:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Firefighter Gas Safety Products]**
 - b. **[Pacific Seismic Products, Inc]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Firefighter Gas Safety Products]**
 - b. **[Pacific Seismic Products, Inc]**
 - c. **<Insert manufacturer's name>**
3. Source Limitation: Obtain earthquake valves from single manufacturer.
4. Description: Seismically activated automatic gas shutoff valve.
5. Standard: ANSI/ASCE/SEI 25.
6. Maximum Operating Pressure: **[10 psig (69 kPa)][60 psig (414 kPa)]<Insert pressure>** .
7. Sight windows for visual indication of valve position.
8. Threaded end connections complying with ASME B1.20.1.
9. Threaded for valves **NPS 4 (DN 100)** and smaller; or flanged for valves **NPS 2 (DN 50)** and larger.
10. Wall-mounting bracket with bubble level indicator.

2.7 PRESSURE REGULATORS

A. Service Pressure Regulator:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Cavagna North America]**
 - b. **[Dresser Utility Solutions]**
 - c. **[Elster-American Meter]**

- d. [Fairview Ltd.]
- e. [Fischer; Emerson Electric Co., Automation Solutions]
- f. [Marshall Excelsior Company]
- g. [Maxitrol Company]
- h. [RegO Products; a brand of Engineered Controls International, LLC]
- i. [Richards Industrials]
- j. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Cavagna North America]
- b. [Dresser Utility Solutions]
- c. [Elster-American Meter]
- d. [Fairview Ltd.]
- e. [Fischer; Emerson Electric Co., Automation Solutions]
- f. [Marshall Excelsior Company]
- g. [Maxitrol Company]
- h. [RegO Products; a brand of Engineered Controls International, LLC]
- i. [Richards Industrials]
- j. <Insert manufacturer's name>

3. Source Limitation: Obtain service pressure regulators from single manufacturer.

4. Standards:

- a. NFPA 58.
- b. CSA/ANSI Z21.80/CSA 6.22.

- 5. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet and no pressure-sensing piping external to the regulator.
- 6. Pressure regulator is to maintain discharge pressure-setting downstream and is not to exceed 150 percent of design discharge pressure at shutoff.
- 7. Maximum Inlet Pressure: **[100 psig (690 kPa)]<Insert pressure>** .
- 8. Maximum Outlet Pressure: **[2 psig (13.8 kPa)][5 psig (34.5 kPa)][10 psig (69 kPa)][20 psig (138 kPa)]<Insert pressure>** .
- 9. End Connections: Threaded for regulators **NPS 2 (DN 50)** and smaller; flanged for regulators **NPS 2-1/2 (DN 65)** and larger.
- 10. Overpressure Protection Device: Factory mounted on pressure regulator.
- 11. Atmospheric Vent: Factory- or field-installed, stainless steel screen in opening if not connected to vent piping.

B. Line-Pressure Regulator:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :

- a. [Cavagna North America]
- b. [Dormont; A Watts Water Technologies Company]
- c. [Dresser Utility Solutions]
- d. [Elster-American Meter]
- e. [Fischer; Emerson Electric Co., Automation Solutions]
- f. [Marshall Excelsior Company]

- g. **[Maxitrol Company]**
 - h. **[RegO Products; a brand of Engineered Controls International, LLC]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cavagna North America]**
 - b. **[Dormont; A Watts Water Technologies Company]**
 - c. **[Dresser Utility Solutions]**
 - d. **[Elster-American Meter]**
 - e. **[Fischer; Emerson Electric Co., Automation Solutions]**
 - f. **[Marshall Excelsior Company]**
 - g. **[Maxitrol Company]**
 - h. **[RegO Products; a brand of Engineered Controls International, LLC]**
 - i. **<Insert manufacturer's name>**
 3. Source Limitation: Obtain line-pressure regulators from single manufacturer.
 4. Standards:
 - a. NFPA 58.
 - b. CSA/ANSI Z21.80/CSA 6.22.
 5. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet and no pressure-sensing piping external to the regulator.
 6. Pressure regulator is to maintain discharge pressure-setting downstream and is not exceed 150 percent of design discharge pressure at shutoff.
 7. Maximum Inlet Pressure: **[2 psig (13.8 kPa)][5 psig (34.5 kPa)][10 psig (69 kPa)]<Insert pressure>** .
 8. Maximum Outlet Pressure: **[2 psig (13.8 kPa)][5 psig (34.5 kPa)]<Insert pressure>** .
 9. End Connections: Threaded for regulators **NPS 2 (DN 50)** and smaller; flanged for regulators **NPS 2-1/2 (DN 65)** and larger.
 10. Overpressure Protection Device: Factory mounted on pressure regulator.
 11. Atmospheric Vent: Factory- or field-installed, stainless steel screen in opening if not connected to vent piping.
- C. Appliance Pressure Regulator:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Cavagna North America]**
 - b. **[Dormont; A Watts Water Technologies Company]**
 - c. **[Dresser Utility Solutions]**
 - d. **[Elster-American Meter]**
 - e. **[Fairview Ltd.]**
 - f. **[Marshall Excelsior Company]**
 - g. **[Maxitrol Company]**
 - h. **[RegO Products; a brand of Engineered Controls International, LLC]**
 - i. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. **[Cavagna North America]**
 - b. **[Dormont; A Watts Water Technologies Company]**
 - c. **[Dresser Utility Solutions]**
 - d. **[Elster-American Meter]**
 - e. **[Fairview Ltd.]**
 - f. **[Marshall Excelsior Company]**
 - g. **[Maxitrol Company]**
 - h. **[RegO Products; a brand of Engineered Controls International, LLC]**
 - i. **<Insert manufacturer's name>**
3. Source Limitation: Obtain appliance pressure regulators from single manufacturer.
 4. Standards:
 - a. NFPA 58.
 - b. CSA/ANSI Z21.18/CSA 6.3.
 5. Regulator may include vent-limiting device, instead of vent connection, if approved by authorities having jurisdiction.
 6. Maximum Inlet Pressure: **[1 psig (6.9 kPa)][2 psig (13.8 kPa)][5 psig (34.5 kPa)]<Insert pressure>** .
 7. Maximum Outlet Pressure: **[1 psig (6.9 kPa)][2 psig (13.8 kPa)]<Insert pressure>** .
 8. End Connections: Threaded for regulators **NPS 2 (DN 50)** and smaller; flanged for regulators **NPS 2-1/2 (DN 65)** and larger.

2.8 SERVICE METERS

A. Diaphragm-Type Service Meter:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Dresser Utility Solutions]**
 - b. **[Elster-American Meter]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dresser Utility Solutions]**
 - b. **[Elster-American Meter]**
 - c. **<Insert manufacturer's name>**
3. Source Limitation: Obtain diaphragm-type service meters from single manufacturer.
4. Standard: **[ANSI B109.1][ANSI B109.2]** .
5. Case: Die-cast aluminum.
6. Connections: Steel threads.
7. Diaphragm: Synthetic fabric.
8. Diaphragm Support Bearings: Self-lubricating.
9. Compensation: Continuous temperature **[and pressure]** .

10. Meter Index: **[Cubic feet][Liters][Cubic feet and liters]** .
11. Meter Case and Index: Tamper resistant.
12. Remote meter reader compatible.
13. Maximum Inlet Pressure: **[100 psig (690 kPa)]<Insert pressure>** .
14. Pressure Loss: Maximum **[0.5 inch wg (124 Pa)][2.0 inch wg (498 Pa)]<Insert pressure differential>** .
15. Accuracy: Maximum plus or minus **[1.0]<Insert number>** percent.

B. Rotary-Type Service Meter:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Dresser Utility Solutions]**
 - b. **[Elster-American Meter]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dresser Utility Solutions]**
 - b. **[Elster-American Meter]**
 - c. **<Insert manufacturer's name>**
3. Source Limitation: Obtain rotary-type service meters from single manufacturer.
4. Standard: ANSI B109.3.
5. Case: Extruded aluminum.
6. Connection: Flange.
7. Impellers: Polished aluminum.
8. Rotor Bearings: Self-lubricating.
9. Compensation: Continuous temperature **[and pressure]** .
10. Meter Index: **[Cubic feet][Liters][Cubic feet and liters]** .
11. Tamper resistant.
12. Remote meter reader compatible.
13. Maximum Inlet Pressure: **[100 psig (690 kPa)]<Insert pressure>** .
14. Accuracy: Maximum plus or minus **[2.0]<Insert number>** percent.

C. Turbine Meter:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Dresser Utility Solutions]**
 - b. **[Elster-American Meter]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dresser Utility Solutions]**

- b. **[Elster-American Meter]**
- c. **<Insert manufacturer's name>**

- 3. Source Limitation: Obtain turbine meters from single manufacturer.
- 4. Standard: ASME MFC.4M.
- 5. Housing: Cast iron or welded steel.
- 6. Connection Threads or Flanges: Steel.
- 7. Turbine: Aluminum or plastic.
- 8. Turbine Bearings: Self-lubricating.
- 9. Compensation: Continuous temperature **[and pressure]** .
- 10. Meter Index: **[Cubic feet][Liters][Cubic feet and liters]** .
- 11. Tamper resistant.
- 12. Remote meter reader compatible.
- 13. Maximum Inlet Pressure: **[100 psig (690 kPa)]<Insert pressure>** .
- 14. Accuracy: Maximum plus or minus **[2.0]<Insert number>** percent.

D. Service-Meter Bar:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Mueller Co.; Gas Products Division; a subsidiary of Mueller Gas Products Inc.]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Mueller Co.; Gas Products Division; a subsidiary of Mueller Gas Products Inc.]**
 - c. **<Insert manufacturer's name>**
- 3. Malleable- or cast-iron frame for supporting service meter.
- 4. Include offset swivel pipes, meter nuts with o-ring seal, and factory- or field-installed dielectric unions.
- 5. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.

E. Service-Meter Bypass Fitting:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A.Y. McDonald Mfg. Co.]**

b. <Insert manufacturer's name>

3. Ferrous, tee, pipe fitting with capped side inlet for temporary LPG supply.
4. Integral ball-check bypass valve.

2.9 DIELECTRIC FITTINGS

A. Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Union:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[HART Industrial Unions, LLC]**
 - c. **[Jomar Valve]**
 - d. **[Matco-Norca]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[HART Industrial Unions, LLC]**
 - c. **[Jomar Valve]**
 - d. **[Matco-Norca]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**
 3. Standard: ASSE/IAMPO/ANSI/CAN 1079.
 4. Pressure Rating: **[125 psig (860 kPa) minimum at 180 deg F (82 deg C)][150 psig (1035 kPa) minimum at 180 deg F (82 deg C)][250 psig (1725 kPa) minimum at 180 deg F (82 deg C)]<Insert pressure rating at temperature>** .
 5. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flange:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Matco-Norca]**
 - b. **[WATTS; A Watts Water Technologies Company]**
 - c. **[Zurn Industries, LLC]**
 - d. **<Insert manufacturer's name>**



2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Matco-Norca]**
 - b. **[WATTS; A Watts Water Technologies Company]**
 - c. **[Zurn Industries, LLC]**
 - d. **<Insert manufacturer's name>**
3. Standard: ASSE/IAMPO/ANSI/CAN 1079.
4. Factory-fabricated, bolted, companion-flange assembly.
5. Pressure Rating: **[125 psig (860 kPa) minimum at 180 deg F (82 deg C)][150 psig (1035 kPa) minimum at 180 deg F (82 deg C)][175 psig (1200 kPa) minimum at 180 deg F (82 deg C)][300 psig (2070 kPa) minimum at 250 deg F (282 deg C)]<Insert pressure>** .
6. End Connections: Solder-joint copper alloy and threaded ferrous; threaded copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kit:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Advance Products & Systems, LLC]**
 - b. **[CALPICO, Inc.]**
 - c. **[GPT Industries, LLC.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advance Products & Systems, LLC]**
 - b. **[CALPICO, Inc.]**
 - c. **[GPT Industries, LLC.]**
 - d. **<Insert manufacturer's name>**
3. Nonconducting materials for field assembly of companion flanges.
4. Pressure Rating: **[150 psig (1035 kPa)]<Insert pressure>** .
5. Gasket: Neoprene or phenolic.
6. Bolt Sleeves: Phenolic or PE.
7. Washers: Phenolic with steel backing washers.

2.10 STORAGE CONTAINERS

A. Storage Container:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Roy E. Hanson Jr. Mfg.]**

- b. **[TransTech Energy, LLC]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Roy E. Hanson Jr. Mfg.]**
 - b. **[TransTech Energy, LLC]**
 - c. **<Insert manufacturer's name>**
3. Description: Factory-designed, -fabricated, and -tested container.
4. Standards:
- a. NFPA 58.
 - b. ASME BPVC-VIII-1.
 - c. ANSI/CAN/UL/ULC 125.
 - d. ANSI/CAN/UL/ULC 842.
 - e. Department of Transportation (DOT) Regulations.
 - f. Provide all appurtenances as required by NFPA 58, qualified to ANSI/CAN/UL/ULC 125.
 - g. Vapor-shutoff valve.
 - h. Liquid-shutoff valve.
 - i. Pressure-relief valve.
 - j. Fixed maximum liquid level gauge.
 - k. Filler valve.
 - l. Overfilling protection device.
 - m. Actuated liquid withdrawal excess-flow valve.
 - n. Provide container appurtenances with a minimum service pressure rating of **250 psig (1724 kPa)**.
5. Provide exposed metal surfaces mechanically cleaned, primed, and painted for resistance to corrosion for outdoor installation.
6. Provide ladders for access to valves more than **72 inches (1830 mm)** aboveground.
7. Stainless Steel Nameplate: Attach to aboveground storage container or to adjacent structure for underground storage container.
- a. Name and address of supplier or trade name of container.
 - b. Water capacity in gallons and liters.
 - c. Design pressure in psig and kPa.
- 1) Statement: "This container does not contain a product having a vapor pressure in excess of **<Insert maximum pressure in psig (kPa) at 100 deg F (37.8 deg C)>**."
 - 2) Outside surface area in square feet and square meters.
 - 3) Year of manufacture.
 - 4) Shell thickness in inches and millimeters.
 - 5) Overall length in feet and meters.
 - 6) OD in feet and meters.
 - 7) Manufacturer's serial number.
 - 8) ASME code label.
- d. Felt support pads and two concrete or painted-steel saddles per storage container. Corrosion protection required at container-to-felt contact.
 - e. Tie straps for each saddle.
 - f. Straps and anchors for tie-down slab.
 - g. Asphalt-based coating for corrosion protection.
 - h. Container connections and valves protected in manway at top of storage container.

- i. Manway equipped with ventilation louvers.

2.11 TRANSPORT TRUCK UNLOADING FACILITY

- A. Transport Truck Unloading Facility: Provide in accordance with the requirements in NFPA 58.
 - 1. Support structure consisting of a minimum **6-inch (150-mm)** steel channel or **6-by-4-inch (150-by-100-mm)** rectangular steel tubing, a minimum of **36 inches (914 mm)** above and below grade.
 - 2. Liquid-fill and vapor-return, quick-disconnect fittings.
 - 3. Liquid- and vapor-shutoff valves with hydrostatic relief valves mounted between the quick-disconnect fittings and shutoff valves.
 - 4. Excess-flow safety shutoff valve in vapor-return line.
 - 5. Backflow check valve in liquid-fill line.
 - 6. Remote emergency shutoff valve station with underground cable to the vapor emergency shutoff valve.

2.12 VAPORIZERS

- A. Vaporizer - Direct-Type, Direct-Fired Heat Exchanger:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Algas-SDI]**
 - b. **[Ransome Manufacturing]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Algas-SDI]**
 - b. **[Ransome Manufacturing]**
 - c. **<Insert manufacturer's name>**
 - 3. Description: Factory-fabricated, -assembled, -calibrated, and -tested vaporizer.
 - 4. Standards:
 - a. NFPA 58.
 - b. ASME BPVC-VIII-1.
 - c. NFPA 70.
 - d. FM Global labeled.
 - 5. ASME-Rated and -Stamped: LPG vaporizer coil contained in an insulated enclosure insulated with a burner.
 - 6. Burner Tubes and Orifices: Stainless steel.
 - 7. Gas Train: Control devices and burner-control sequence are to be FM Global labeled. Provide shutoff valve, high- and low-pressure safety switches, pressure regulator, and main- and pilot-control valves.
 - 8. Burner Operating Controls:

- a. Controls are to maintain safe operating conditions.
 - b. High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design pressure.
 - c. Operating Vapor-Pressure Control: Factory piped and mounted to control burner.
- B. Vaporizer - Indirect-Type, Direct-Fired Heat Exchanger:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Algas-SDI]**
 - b. **[Ransome Manufacturing]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Algas-SDI]**
 - b. **[Ransome Manufacturing]**
 - c. **<Insert manufacturer's name>**
 - 3. Description: Factory-fabricated, -assembled, -calibrated, and -tested vaporizer.
 - 4. Standards:
 - a. NFPA 58.
 - b. ASME BPVC-VIII-1.
 - c. NFPA 70.
 - d. FM Global labeled.
 - 5. ASME-Rated and -Stamped: LPG vaporizer vessel with a replaceable, immersion-type, electric heating element.
 - 6. Heating Element Operating Controls:
 - a. Controls are to maintain safe operating conditions.
 - b. Operating Vapor-Pressure Control: Factory wired and mounted to control heating element.
 - c. High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design pressure.
 - d. Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; is to sound alarm for out-of-normal conditions.
 - e. Control Transformer: 115 V maximum control voltage.
- C. Vaporizer - Direct-Type, Water-Bath Heat Exchanger:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Algas-SDI]**
 - b. **[Alternate Energy Systems, Inc]**
 - c. **[Ransome Manufacturing]**
 - d. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Algas-SDI]**
 - b. **[Alternate Energy Systems, Inc]**
 - c. **[Ransome Manufacturing]**
 - d. **<Insert manufacturer's name>**
3. Description: Factory-fabricated, -assembled, -calibrated, and -tested vaporizer.
4. Standards:
 - a. NFPA 58.
 - b. ASME BPVC-VIII-1.
 - c. NFPA 70.
 - d. FM Global labeled.
5. ASME-Rated and -Stamped: Helical LPG vaporizer coil submerged in water bath. Straight, steel fire tubes welded into steel headers.
6. Water Bath:
 - a. Water bath filled with water/glycol solution designed to prevent freezing at **[minus 30 deg F (minus 34 deg C)]<Insert temperature>** .
 - b. Water-bath, high- and low-level sight glasses.
 - c. Low-water cutoff to stop burner and annunciate alarm.
 - d. Water/glycol fill and vent fitting.
 - e. Minimum **NPS 3/4 (DN 20)** hose-end drain valves.
 - f. Operating high- and low-limit aquastat controllers.
 - g. Water-bath temperature gauge; a minimum of **2-1/2 inches (63 mm)** in diameter. Gauges are to have operating-temperature ranges, so normal operating range is at approximately 50 percent of full range.
7. Burner Tubes and Orifices: Stainless steel.
8. Gas Train: Control devices and burner-modulation control sequence is to be FM Global labeled. Provide shutoff valve, high- and low-pressure safety switches, pressure regulator, and main- and pilot-control valves.
9. Burner Operating Controls:
 - a. Operating controls are to maintain safe operating conditions.
 - b. Operating Water-Bath Temperature Control: Factory wired and mounted to control burner.
 - c. High-Temperature and High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design temperature or vapor pressure.
 - d. Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; is to sound alarm for out-of-normal conditions.
 - e. Control Transformer: 115 V maximum control voltage.

D. Vaporizer - Indirect-Type, Heat Exchanger:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Algas-SDI]**
 - b. **[Alternate Energy Systems, Inc]**

- c. **[Ransome Manufacturing]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Algas-SDI]**
 - b. **[Alternate Energy Systems, Inc]**
 - c. **[Ransome Manufacturing]**
 - d. **<Insert manufacturer's name>**
3. Description: Factory-fabricated, -assembled, -calibrated, and -tested vaporizer.
4. Standards:
 - a. NFPA 58.
 - b. ASME BPVC-VIII-1.
 - c. NFPA 70.
 - d. FM Global labeled.
5. ASME-Rated and -Stamped: LPG vaporizer with immersion tubes containing **[steam][hot water]** and LPG in surrounding shell.
6. Operating Controls:
 - a. Controls are to maintain safe operating conditions.
 - b. High-Temperature and High-Pressure Cutoff: Manual reset if operating conditions rise above maximum design temperature or pressure.
 - c. Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; sound alarm for out-of-normal conditions.
 - d. Control Transformer: 115 V maximum control voltage.
- E. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control set points and display vaporizer status and alarms.
- F. Capacities and Characteristics:
 1. Heating Fuel: **[Propane][Butane][Electric]** .
 2. Vaporization Heat Exchanger:
 - a. Minimum Working-Pressure Rating: **[250 psig (1723 kPa)]<Insert value>** .
 - b. Test Pressure: **[375 psig (2586 kPa)]<Insert value>** .
 3. LPG Vaporization Rate: **<Insert gph (mL/s)>** .
 4. Entering-LPG Temperature: **[Minus 30 deg F (Minus 34 deg C)]<Insert temperature>** .
 5. Leaving-LPG Temperature: **[80 deg F (26.7 deg C)]<Insert temperature>** .
 6. Discharge-LPG Pressure: **[90 psig (621 kPa)]<Insert value>** .
 7. Burner Gas Input: **<Insert Btu/h (kW)>** .
 8. Electric Burner Input: **<Insert kilowatts>** .
 9. Water-Bath Vaporizers:
 - a. Operating Pressure: **[Atmospheric]<Insert psig (kPa)>** .
 - b. Operating Temperature: **[160 deg F (71 deg C)]<Insert temperature>** .
 10. Electrical Characteristics:
 - a. Volts: **[120][240][480]<Insert number>** V.

- b. Phase: **[Single][Three]** .
- c. Hertz: 60.
- d. Minimum Circuit Ampacity: **<Insert number> A.**
- e. Maximum Overcurrent Protection: **<Insert number> A.**

2.13 DETECTABLE WARNING TAPE

- A. Acid- and alkali-resistant PE film warning tape manufactured for marking and identifying underground utilities, a minimum of **6 inches (150 mm)** wide and **4 mils (0.1 mm)** thick, continuously inscribed with a description and rated pressure of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to **30 inches (750 mm)** deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for LPG piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 PREPARATION

- A. Close equipment-shutoff valves before turning off LPG to premises or piping section.
- B. Inspect LPG piping in accordance with **[NFPA 58,][the International Fuel Gas Code,]** and requirements of authorities having jurisdiction to determine that LPG utilization devices are turned off in piping section affected.
- C. Comply with **[NFPA 58,][the International Fuel Gas Code,]** and requirements of authorities having jurisdiction for prevention of accidental ignition.

3.4 INSTALLATION OF PIPE, TUBING, AND FITTINGS

- A. Outdoor Pipe:
 - 1. Comply with **[NFPA 58,][the International Fuel Gas Code,]** and requirements of authorities having jurisdiction for installation and purging of LPG piping.
 - 2. Install underground, LPG piping buried a minimum of **[12 inches (300 mm)]<Insert dimension>** below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.
 - a. If LPG piping is installed less than **12 inches (300 mm)** below finished grade, install it in

containment conduit.

3. Install underground, PE, natural-gas piping in accordance with ASTM D2774.
4. Steel Piping with Protective Coating:
 - a. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - c. Replace pipe having damaged PE coating with new pipe.

B. Copper Tubing with Protective Coating:

1. Apply joint cover kits over tubing to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Install fittings for changes in direction and branch connections.
4. Joints for connection to inlets and outlets on vaporizers, regulators, and valves may be flanged or threaded to match the equipment.
5. Install pressure gauge [**downstream**][**upstream and downstream**] from each service regulator. Pressure gauges are specified in Section 230500 "Common Work Results for HVAC."

C. Indoor Pipe:

1. Comply with [**NFPA 58,**][**the International Fuel Gas Code,**] and requirements of authorities having jurisdiction for installation and purging of LPG piping.
2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
3. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
4. Install piping in concealed locations unless otherwise indicated on Drawings. Piping in equipment rooms and service areas may be installed exposed. Piping is not to be installed in inaccessible locations.
 - a. Conceal piping in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
 - b. Except as specified below, install concealed piping and piping installed under the building in containment conduit in accordance with [**NFPA 58,**][**the International Fuel Gas Code,**] and requirements of authorities having jurisdiction. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
 - 1) Above Accessible Ceilings: Piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
 - a) Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
 - 2) In Floors: Install piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of **1-1/2 inches (38 mm)** of concrete. Piping may not be in physical contact with other metallic structures, such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
 - 3) In Floor Channels: Channels must have cover and be open to space above cover for ventilation.
 - 4) In Walls or Partitions: Protect piping installed inside partitions or hollow walls from

physical damage using steel striker barriers at rigid supports.

- a) Exception: Piping passing through partitions or walls does not require striker barriers.
 - c. Prohibited Locations:
 - 1) Do not install piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - 2) Do not install piping in return-air plenums.
 - 3) Do not install piping in solid walls or partitions.
 - d. Under the Building: Install in vented containment conduit or CSST with integral vented sleeve and associated fittings.
- 5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise on Drawings.
 - 6. Locate valves for easy access from a standing position. Do not locate valves within return air plenums.
 - 7. Install LPG piping at uniform grade of 2 percent down toward drip and sediment traps.
 - 8. Install piping free of sags and bends.
 - 9. Install fittings for changes in direction and branch connections.
 - 10. Comply with requirements in Sections specifying gas-fired appliances and equipment, and verify final appliance and equipment locations for roughing-in requirements.
 - 11. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where readily accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - a. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of three pipe diameters, but not less than **3 inches (75 mm)** long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
 - 12. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors, and terminate with weatherproof vent cap.
 - 13. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
 - 14. Connect branch piping from top or side of horizontal piping.
 - 15. Install unions in pipes **NPS 2 (DN 50)** and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
 - 16. Do not use LPG piping as grounding electrode.
 - 17. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve. Remove and replace startup strainer with new strainer prior to final acceptance tests.
 - 18. Install pressure gauge [**downstream**][**upstream and downstream**] from each line regulator. Pressure gauges are specified in Section 230500 "Common Work Results for HVAC."
 - 19. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."
 - 20. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common Work Results for HVAC."
 - 21. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

3.5 INSTALLATION OF SERVICE METERS

- A. Install service-meter assemblies aboveground [, **on concrete bases**] .
- B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.
- C. Install strainer on inlet of service-pressure regulator and meter set.
- D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.
- E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.
- F. Install service meters downstream from pressure regulators.
- G. Install metal bollards to protect meter assemblies. Comply with requirements in Section 055000 "Metal Fabrications" for pipe bollards.

3.6 INSTALLATION OF PRESSURE REGULATORS

- A. Ensure the gas supply is completely shut off at the main valve and that the line is fully depressurized.
- B. Remove any shipping plugs from the inlet, outlet, and vent connections. Ensure the pipe interior and regulator are free of dirt, debris, and contaminants.
- C. Apply pipe joint sealant or Teflon tape rated for gas use to the male threads of the pipe. Avoid getting sealant on the female threads or inside the regulator.
- D. Mount the regulator in the correct orientation, aligning the flow arrow on the body with the direction of gas flow. The piping must be properly aligned and supported to avoid stressing the regulator.
- E. If the pressure regulator is installed inside of a building, install a dedicated vent line directly from the regulator to the outdoors. The vent terminal must be insect resistant and rain resistant. The regulator should be at least **3 ft. (914 mm)** horizontally from any building opening below the vent opening and positioned so that gas can disperse freely.

3.7 INSTALLATION OF GAS VALVES

- A. Install manual gas shutoff valve for each gas appliance ahead of CSST, aluminum, or copper connector.
- B. Install underground valves with valve boxes.
- C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- D. Install earthquake valves aboveground outside buildings according to listing.
- E. Install anode for metallic valves in underground PE piping.
- F. Do not install valves in return-air plenums.

3.8 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full ID of pipe.
 - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints:
 - 1. Construct joints in accordance with AWS D10.12/D10.12M, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
 - 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- E. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
- F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for LPG service. Install gasket concentrically positioned.
- G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.
- H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join in accordance with ASTM D2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.9 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- C. Install hangers for **[steel piping][and][copper tubing]** , with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and requirements of authorities having jurisdiction, whichever are most stringent.
- D. Install hangers for corrugated stainless steel tubing, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and requirements

of authorities having jurisdiction, whichever are most stringent.

- E. Support horizontal piping within [**12 inches (300 mm)**]**<Insert dimension>** of each fitting.
- F. Support vertical runs of [**steel piping**]**[and][copper tubing]** to comply with MSS SP-58, locally enforced codes, and requirements of authorities having jurisdiction, whichever are most stringent.
- G. Support vertical runs of corrugated stainless steel tubing to comply with manufacturer's written instructions, locally enforced codes, and requirements of authorities having jurisdiction, whichever are most stringent.

3.10 PIPING CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install LPG piping electrically continuous, and bonded to gas-appliance equipment grounding conductor of the circuit powering the appliance in accordance with NFPA 70.
- C. Install piping adjacent to appliances to allow service and maintenance of appliances.
- D. Connect piping to appliances using manual gas-shutoff valves and unions. Install valve within **72 inches (1830 mm)** of each gas-fired appliances and equipment. Install union between valve and appliances or equipment.

3.11 INSTALLATION OF TRANSPORT TRUCK UNLOADING FACILITY

- A. Install transport truck unloading in a cast-in-place concrete base, **48 inches (1220 mm)** square by **36 inches (914 mm)** deep. Set top of concrete base at least **6 inches (150 mm)** above finished grade.
- B. Install remote emergency shutoff station with cable release in an accessible location, a minimum of **25 ft. (7.6 m)** and a maximum of **100 ft. (30 m)** away from transport truck unloading.
- C. Install at least two **6-inch- (150-mm-)** diameter metal bollards set in and filled with concrete on both sides of transport truck unloading. Bollard length is to be at least **48 inches (1220 mm)** above and below grade, with concrete encasement a minimum of **12 inches (300 mm)** in diameter.

3.12 INSTALLATION OF STORAGE CONTAINER

- A. Do not install storage containers in a pit.
- B. Fill storage container to at least 80 percent capacity with [**butane**]**[propane]** .
- C. Install piping connections with swing joints or flexible connectors to allow for storage container settlement and for thermal expansion and contraction.
- D. Ground containers in accordance with NFPA 780. Grounding is specified in Section 264113 "Lightning Protection for Structures."
- E. Set storage containers in felt pads on concrete or steel saddles. Install corrosion protection at container-to-felt contact.
- F. Install tie-downs over storage containers on saddles with proper tension.



- G. Set concrete saddles on dowels set in concrete base. Anchor steel saddles to concrete base.
- H. Set storage container on concrete ballast base large enough to offset buoyancy of empty storage container immersed in water.
- I. Install tie-down straps over container anchored in ballast base, and repair damaged coating.
- J. Backfill with a minimum coverage for underground or mounded storage containers in accordance with NFPA 58.
- K. Backfill with pea gravel as required in Section 312000 "Earth Moving."
- L. Install cathodic protection for storage container. Cathodic protection is specified in Section 134713 "Cathodic Protection."

3.13 INSTALLATION OF VAPORIZER

- A. Install vaporizer with access space for periodic maintenance.
- B. Set vaporizers on and anchor to concrete base.
- C. Connect liquid line from pump set, and connect vapor supply to distribution piping.
- D. Install backup connection from vapor space of container to inlet of pressure-regulating valve at vaporizer discharge to bypass the vaporizer during maintenance. Install shutoff valves to change source from vaporizer to storage container.

3.14 INSTALLATION OF LABELING AND IDENTIFICATION

- A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, **12 inches (305 mm)** below finished grade, except **6 inches (150 mm)** below subgrade under pavements and slabs.
- C. Label and identify gas piping and pressure outside a multitenant building by tenant.

3.15 CONCRETE BASES

- A. Anchor equipment to concrete base [.] **in accordance with seismic codes of Project. See Section 230548 "Vibration and Seismic Controls for HVAC."**
- B. Construct concrete bases of dimensions indicated, but not less than **4 inches (100 mm)** larger in both directions than supported unit.
- C. Install dowel rods to connect concrete base to concrete floor. Install dowel rods on **[18-inch (451-mm)]<Insert dimension>** centers around the full perimeter of the base.
- D. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

- E. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
- F. Install anchor bolts to elevations required for proper attachment to supported equipment.
- G. Use **[3000 psig (20.7 MPa)]<Insert value>**, 28-day, compressive-strength concrete and reinforcement, as specified in Section 033000 "Cast-in-Place Concrete."

3.16 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Comply with **[NFPA 58,][the International Fuel Gas Code,]** and requirements of authorities having jurisdiction for testing, inspection, and purging of LPG installation.
 - 2. LPG installation will be considered defective if it does not pass tests and inspections. Defective products are to be replaced. Retest installation after defective products have been replaced for code compliance.
- B. Prepare test and inspection reports.

3.17 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain LPG equipment.

3.18 OUTDOOR LPG PIPING SCHEDULE

- A. Underground LPG Piping: To be one of the following:
 - 1. PE Pipe, Tubing, and Fittings: Terminate service-line risers with tracer wire in an accessible location.
 - 2. Polyamide Pipe, Tubing, and Fittings: Terminate in an accessible location.
 - 3. Steel Pipe: With wrought-steel welding fittings or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
 - 4. Drawn-Temper Copper Tube: With copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
 - 5. Annealed-Temper Copper Tube: With copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
 - 6. Containment Conduit: In accordance with **[NFPA 58,][the International Fuel Gas Code,]** and requirements of authorities having jurisdiction.
 - 7. CSST and Fittings: With integral vented sleeve terminated in an accessible location.
- B. Aboveground LPG Piping: To be one of the following:
 - 1. CSST and fittings.
 - 2. Steel Pipe: With **[malleable-iron threaded fittings][wrought-steel welded fittings or mechanical couplings]**.
 - 3. Drawn-Temper Copper Tube: With wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
 - 4. Annealed-Temper Copper Tube: With copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.

C. Branch Piping in Cast-in-Place Concrete to Single Appliance:

1. Annealed-Temper Copper Tube: With wrought-copper fittings and **[brazed][flared]** joints. Install piping embedded in concrete with no joints in concrete. Coat pipe and fittings with protective coating for copper tubing.

3.19 INDOOR LPG PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 kPa)

A. Aboveground Piping: To be one of the following:

1. CSST and Fittings.
2. Tin-Lined Copper Tube: With flared joints and fittings.
3. Annealed-Temper Copper Tube: With wrought-copper fittings and **[brazed][flared]** joints.
4. Aluminum Tube: With flared fittings and joints.
5. Steel Pipe: With **[malleable-iron threaded][wrought-steel welding]** fittings.
6. Drawn-Temper Copper Tube: With wrought-copper fittings and brazed joints.

B. Underground (Below Building) Piping: To be one of the following:

1. Steel Pipe: With **[malleable-iron threaded][wrought-steel welding]** fittings.
2. Containment Conduit: In accordance with **[NFPA 58,][the International Fuel Gas Code,]** and requirements of authorities having jurisdiction.
3. Containment Conduit Vent Piping: In accordance with **[NFPA 58,][the International Fuel Gas Code]** and requirements of authorities having jurisdiction.

3.20 INDOOR LPG PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG (3.45 kPa) AND LESS THAN 5 PSIG (34.5 kPa)

A. Aboveground Piping: To be one of the following:

1. CSST and fittings.
2. Tin-Lined Copper Tube: With flared joints and fittings.
3. Annealed-Temper Copper Tube: With wrought-copper fittings and **[brazed][flared]** joints.
4. Aluminum Tubing and Piping: With flared fittings and joints.
5. Steel Pipe: With malleable-iron threaded fittings.
6. Schedule 40, steel pipe with steel welding fittings.
7. Drawn-Temper Copper Tube: With wrought-copper fittings and brazed joints.

B. Underground (Below Building) Piping: To be one of the following:

1. Steel Pipe: With **[malleable-iron threaded][wrought-steel welding]** fittings.
2. Containment Conduit: In accordance with **[NFPA 58,][the International Fuel Gas Code,]** and requirements of authorities having jurisdiction.
3. Containment Conduit Vent Piping: In accordance with **[NFPA 58,][the International Fuel Gas Code,]** and requirements of authorities having jurisdiction.

3.21 INDOOR LPG PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 5 PSIG (34.5 kPa)

A. Aboveground Piping: Maximum operating pressure more than **[5 psig (34.5 kPa)]<Insert pressure>** .

1. Steel Pipe: With wrought-steel welding fittings.

2. Drawn-Temper Copper Tube: With wrought-copper fittings and brazed joints.
- B. Underground (Below Building) Piping: To be the following:
 1. Steel Pipe: With **[malleable-iron threaded][wrought-steel welding]** fittings.
 2. Containment Conduit: In accordance with **[NFPA 58,][the International Fuel Gas Code,]** and requirements of authorities having jurisdiction.
 3. Containment Conduit Vent Piping: In accordance with **[NFPA 58,][the International Fuel Gas Code,]** and requirements of authorities having jurisdiction.

3.22 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.
- B. Underground Vapor Piping:
 1. Manual gas shutoff ball valve - PE.
 2. Manual gas shutoff valve - metallic.

3.23 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Aboveground LPG Piping: Manual gas shutoff valve - metallic.

END OF SECTION 23 11 26 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 11 26 00	21 05 00 00	Common Work Results for Fire Suppression
23 11 26 00	22 05 00 00	Common Work Results for Plumbing
23 11 26 00	22 13 16 00	Sanitary Waste And Vent Piping
23 11 26 00	23 05 00 00	Common Work Results for HVAC
23 11 26 00	22 12 23 26	Facility Fuel-Oil Piping
23 11 26 00	23 11 23 00	Facility Natural-Gas Piping
23 11 26 00	33 11 13 00a	Potable Water Supply Wells



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 12 13 00 - FACILITY FUEL-OIL PUMPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Submersible fuel-oil storage tank pumps.
 2. Fuel-oil pumps - simplex.
 3. Fuel-oil pumps - multiplex.
 4. Fuel-oil polishing systems.

1.2 ACTION SUBMITTALS

- A. Product Data:
1. Submersible fuel-oil storage tank pumps.
 2. Fuel-oil pumps - simplex.
 3. Fuel-oil pumps - multiplex.
 4. Fuel-oil polishing systems.
- B. Product Data Submittals: For each product.
1. Include construction details, material descriptions, and dimensions of individual components and profiles.
 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- C. Shop Drawings: For fuel-oil pumps[**and fuel-oil polishing systems**].
1. Include construction details and dimensions of individual components for fuel-oil pumps.
 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 3. Scale: [1/4 inch per foot (1:50)]<Insert scale>.
- D. Delegated Design Submittals: For vibration isolation[**and seismic restraints**] indicated to comply with performance requirements and design criteria, including analysis data[**signed and sealed by the qualified professional engineer responsible for their preparation**].
1. Detail fabrication and assembly of anchors[**and seismic restraints**].
 2. Design Calculations: Calculate requirements for selecting seismic restraints.
 3. Detail fabrication and assembly of hangers, supports, and attachments of the same to building structure.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and details, or Building Information Model (BIM), drawn to scale, showing items described in this Section and coordinated with all building trades.



- B. Seismic Qualification Certificates: For fuel-oil pumps[, **and fuel-oil polishing systems,**] from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.
- D. Qualification Statements: For professional engineer.
- E. Sample Warranties: For [**fuel-oil pumps**][**fuel-oil polishing system**].

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-oil pumps[**and fuel-oil polishing systems**].

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials[, **from the same production run,**] to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Drive Belt: [**One**]<Insert number> for each belt-driven pump.

1.6 QUALITY ASSURANCE

- A. Delegated Design Engineer Qualifications: A professional engineer who is legally qualified to practice in [**state**]<Insert jurisdiction> where Project is located and who is experienced in providing engineering services of the type indicated.

1.7 WARRANTY

- A. Manufacturer Warranty: [**Manufacturer agrees**][**Installer agrees**][**Manufacturer and installer agree**] to repair or replace fuel-oil pumps[**and fuel-oil polishing systems**] that fail in materials or workmanship within specific warranty period.
- B. Warranty Period for Fuel-Oil Pumps: <Insert number> year(s) from date of Substantial Completion.
- C. Warranty Period for Fuel-Oil Polishing Systems: <Insert number> year(s) from date of Substantial Completion.



PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
- B. Maximum Operating-Pressure Ratings: **[3 psig (21 kPa)]<Insert pressure>** fuel-oil supply pressure at oil-fired appliances.
- C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design restraint and anchors for fuel-oil pumps **[and fuel-oil polishing systems]**, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- D. Seismic Performance: Factory-installed support attachments for pumps **[and fuel-oil polishing systems]** are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]**."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- E. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.

2.2 SUBMERSIBLE FUEL-OIL STORAGE TANK PUMPS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Franklin Fueling Systems]**
 - 2. **[Red Jacket Pumps]**
 - 3. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Franklin Fueling Systems]**
 - 2. **[Red Jacket Pumps]**
 - 3. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain submersible fuel-oil storage tank pumps from single manufacturer.
- D. Comply with UL 79, UL 87, and UL 343.
 - 1. Impeller: Turbine.
 - 2. Housing and Volute: Cast iron.
 - 3. Bearings: Bronze, self-lubricating.
 - 4. Seals: Mechanical.

5. Shaft: Polished steel.
6. Suspension Piping: Telescoping to accommodate tank diameter and depth of bury.
7. Base: Steel.
8. Pressure Relief: Built in.
9. Discharge Check Valve: Built in.
10. Drive: Direct, close coupled.

E. Controls: Pump controller panel complying with UL 353 and UL 508C and with interlock and terminals for connections to fuel-oil-burning equipment.

1. Maintain minimum manifold pressure with outdoor-air temperature less than [60 deg F (16 deg C)]<Insert temperature>.
2. Seven-day schedule.
3. Stage multiple pumps to maintain pressure at a common supply manifold.
4. Alternate pumps to equalize run time.
5. Alarm motor failure.
6. Manual reset dry-run protection.
7. Stop pumps if fuel level falls below pump suction.
8. De-energize and sound alarm for pump, locked-rotor condition.
9. Sound alarm for open circuit and for high and low voltage.
10. Lights indicate normal power on, run, and off conditions.
11. Interface with automatic control system. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" to control and indicate the following:
 - a. Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
 - b. Operating status.
 - c. Alarm off-normal status.

F. Capacities and Characteristics:

1. Number of Stages: <Insert number>.
2. Capacity: <Insert gph (L/s)>.
3. Discharge Pressure: <Insert psig (kPa)>.
4. Outlet Size: <Insert NPS (DN)>.
5. Motor Speed: <Insert rpm>.
6. Motor Horsepower: <Insert value>.
7. Electrical Characteristics:
 - a. Volts: [120][208][240]<Insert value>.
 - b. Phase: [Single][Three].
 - c. Hertz: 60.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

2.3 FUEL-OIL PUMPS - SIMPLEX

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [DESMI INC./Rotan Pumps]
2. [Earthsafe Systems, Inc.]

3. [Haight Pumps; a division of Baker Mfg.]
 4. [Preferred Utilities Manufacturing Corporation]
 5. [Suntec Industries Incorporated]
 6. [Tuthill Corporation]
 7. [Viking Pump Inc.; a unit of IDEX Corporation]
 8. [Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.]
 9. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [DESMI INC./Rotan Pumps]
 2. [Earthsafe Systems, Inc.]
 3. [Haight Pumps; a division of Baker Mfg.]
 4. [Preferred Utilities Manufacturing Corporation]
 5. [Suntec Industries Incorporated]
 6. [Tuthill Corporation]
 7. [Viking Pump Inc.; a unit of IDEX Corporation]
 8. [Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.]
 9. <Insert manufacturer's name>
- C. Source Limitations: Obtain fuel-oil pumps - simplex, from single manufacturer.
- D. Description: Comply with UL 343 and HI 3.1-3.5.
1. Type: Positive-displacement, rotary type.
 2. Impeller: [Steel gear with crescent][Carbon vane].
 3. Housing: Cast-iron foot mounted.
 4. Bearings: Bronze, self-lubricating.
 5. Shaft: Polished steel.
 6. Seals: Mechanical.
 7. Base: Steel.
 8. Pressure Relief: Built in.
 9. Discharge Check Valve: Built in.
- E. Drive: [V-belt with guard; gear reducer; or direct, close coupled][V-belt with guard][Gear reducer][Direct, close coupled].
- F. Controls:
1. Maintain minimum manifold pressure with outdoor-air temperature less than [60 deg F (16 deg C)]<Insert temperature>.
 2. Seven-day schedule.
 3. Alarm motor failure.
 4. Manual reset dry-run protection.
 5. Stop pump if fuel level falls below pump suction.
 6. De-energize and sound alarm for pump, locked-rotor condition.
 7. Sound alarm for open circuit and for high and low voltage.
 8. Lights are to indicate normal power on, run, and off conditions.
 9. Interface with automatic control system. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" to control and indicate the following:
 - a. Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
 - b. Operating status.
 - c. Alarm off-normal status.

G. Capacities and Characteristics:

1. Number of Stages: **<Insert number>**.
2. Capacity: **<Insert gph (L/s)>**.
3. Inlet Vacuum: **<Insert inches Hg (kPa)>**.
4. Discharge Pressure: **<Insert psig (kPa)>**.
5. Inlet and Outlet Size: **<Insert NPS (DN)>**.
6. Motor Speed: **<Insert rpm>**.
7. Motor Horsepower: **<Insert value>**.
8. Electrical Characteristics:
 - a. Volts: **[120][208][240]<Insert value>**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.4 FUEL-OIL PUMP SETS - MULTIPLEX**A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Alyan Pump Company]**
2. **[Earthsafe Systems, Inc.]**
3. **[Flo Fab Inc]**
4. **[Hydronic Modules Company]**
5. **[Preferred Utilities Manufacturing Corporation]**
6. **[Smith-Koch, Inc]**
7. **[Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.]**
8. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. **[Alyan Pump Company]**
2. **[Earthsafe Systems, Inc.]**
3. **[Flo Fab Inc]**
4. **[Hydronic Modules Company]**
5. **[Preferred Utilities Manufacturing Corporation]**
6. **[Smith-Koch, Inc]**
7. **[Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.]**
8. **<Insert manufacturer's name>**

C. Source Limitations: Obtain fuel-oil pump sets - multiplex, from single manufacturer.**D. Description: Comply with HI 3.1-3.5.**

1. Type: Positive-displacement, rotary type.
2. Configuration: **[Duplex][Triplex]**.
3. Impeller: **[Steel gear with crescent][Carbon vane]**.
4. Housing: Cast-iron foot mounted.
5. Bearings: Bronze, self-lubricating.

6. Shaft: Polished steel.
 7. Seals: Mechanical.
 8. Base: Steel.
 9. Pressure Relief: Built in.
 10. Discharge Check Valve: Built in.
- E. Drive: **[V-belt with guard, gear reducer, or direct close coupled][V-belt with guard][Gear reducer][Direct close coupled]**.
- F. Controls:
1. Maintain minimum manifold pressure with outdoor-air temperature less than **[60 deg F (16 deg C)]<Insert temperature>**.
 2. Seven-day schedule.
 3. Stage multiple pumps to maintain pressure at a common supply manifold.
 4. Alternate pumps to equalize run time.
 5. Alarm motor failure.
 6. Manual reset dry-run protection.
 7. Stop pumps if fuel level falls below pump suction.
 8. De-energize and sound alarm for pump, locked-rotor condition.
 9. Sound alarm for open circuit and for high and low voltage.
 10. Lights indicate normal power on, run, and off conditions.
 11. Interface with automatic control system. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" to control and indicate the following:
 - a. Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
 - b. Operating status.
 - c. Alarm off-normal status.
- G. Piping Furnished with Pumps: Steel with ferrous fittings and threaded or welded joints.
- H. Strainers Furnished with Pumps: Duplex, basket type with corrosion-resistant-metal-screen baskets.
- I. Capacities and Characteristics:
1. Number of Stages: **<Insert number>**.
 2. Capacity (Each Pump): **<Insert gph (L/s)>**.
 3. Inlet Vacuum: **<Insert inches Hg (kPa)>**.
 4. Discharge Pressure: **<Insert psig (kPa)>**.
 5. Inlet and Outlet Size: **<Insert NPS (DN)>**.
 6. Motor Speed: **<Insert rpm>**.
 7. Motor Horsepower (Each Pump): **<Insert value>**.
 8. Electrical Characteristics (Pump Set):
 - a. Volts: **[120][208][240]<Insert value>**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.5 FUEL-OIL POLISHING SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide**

products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Earthsafe Systems, Inc.]
2. [Fuel Technologies International]
3. [Fuel-Vu, a division of Unified Services of Texas, Inc.]
4. [Fueltec Systems, LLC]
5. [Preferred Utilities Manufacturing Corporation]
6. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Earthsafe Systems, Inc.]
2. [Fuel Technologies International]
3. [Fuel-Vu, a division of Unified Services of Texas, Inc.]
4. [Fueltec Systems, LLC]
5. [Preferred Utilities Manufacturing Corporation]
6. <Insert manufacturer's name>

C. Source Limitations: Obtain fuel-oil polishing system from single manufacturer.

D. Description: Factory-fabricated and -wired, fuel-oil polishing system for fuel-oil filtration; with enclosure, filter, fuel-oil pump, and controls.

1. System to be FM Global approved and be listed and labeled an NRTL acceptable to authorities having jurisdiction.
2. Enclosure: NEMA 250, Type 3R, painted steel containing pumps, filters, accessories, and controls. Hinged door on the front of enclosure.
3. Pump: Comply with HI 3.1-3.5, steel gear with crescent, positive-displacement, direct-coupled, rotary type.
4. Materials: Cast-iron housing; bronze bearings; steel shaft; mechanical seals; and built-in, pressure relief bypass valve.
5. Piping: Steel with malleable-iron fittings and threaded joints or wrought-steel fittings and welded joints.
6. Spin-on, Replaceable, Multistage Filters:
 - a. Stage 1: 100-mesh strainer.
 - b. Stage 2: Centrifuge to separate particulates and water from oil.
 - c. Stage 3: Coalescing water and particulate filter.
 - d. Stage 4: 30-micron particulate removal.
 - e. Stage 5: 10-micron particulate removal.
 - f. Stage 6: Minimum 99.5 percent water removal with see-through bowl and water-sensor probe.
 - g. Stage 7: Minimum 99 percent [1.5][3][5]-micron particulate removal.
7. Multiple-Tank Manifolds:
 - a. Manifold fabricated of Schedule 80, black steel pipe and threaded nipples for [two][three][four] tanks.
 - b. Solenoid valves for supply and return piping to each tank.
 - c. Strainers for each tank supply connection.
8. Programmable Logic Controller:

- a. Provide fully automatic operation of system.
 - b. Alarm on maximum **15 in. Hg (51 kPa)** vacuum at pump suction indicating plugged filter.
 - c. Alarm on high water level in filter.
 - d. Alarm on leak in enclosure.
 - e. Touchscreen; with minimum 2-line, 20-character, illuminated digital display.
 - f. Display pressure differential across filter.
 - g. Display pressure differential across coalescer.
 - h. Controller strip heater with thermostat.
9. Fuel-Quality Analyzer: Continuously monitors fuel quality to detect and record particulate contamination and presence of water.
 10. Interface with automatic control system is specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" to control and indicate the following:
 - a. Start/stop system when required by schedule.
 - b. Operating status.
 - c. Alarm off-normal status.

E. Pump Capacities and Characteristics:

1. Capacity (Each Pump): [**3 gpm (0.19 L/s)**][**8 gpm (0.50 L/s)**][**24 gpm (1.5 L/s)**]**<Insert value>**.
2. Maximum Suction Lift: [**15 ft. (4.6 m)**]**<Insert value>**.
3. Inlet and Outlet Size: **<Insert NPS (DN)>**.
4. Motor Horsepower (Each Pump): **<Insert value>**.
5. Electrical Characteristics (Pump Set):
 - a. Volts: [**120**][**208**][**240**]**<Insert value>**.
 - b. Phase: [**Single**][**Three**].
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.6 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 1. Enclosure: [**Open, dripproof**][**Totally enclosed, fan cooled**][**Totally enclosed, air over**][**Open, externally ventilated**][**Totally enclosed, nonventilated**][**Severe duty**][**Explosion proof**][**Dust-ignition-proof machine**].
 2. Enclosure Materials: [**Cast iron**][**Cast aluminum**][**Rolled steel**].
 3. Motor Bearings: **<Insert requirements>**.
 4. Unusual Service Conditions:
 - a. Ambient Temperature: **<Insert deg C>**.
 - b. Altitude: **<Insert feet (m)>** above sea level.
 - c. High humidity.
 - d. **<Insert conditions>**.
 5. Efficiency: Premium efficient.
 6. NEMA Design: **<Insert designation>**.
 7. Service Factor: **<Insert value>**.



PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for fuel-oil pumps to verify actual locations of pump connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 PREPARATION

- A. Close equipment shutoff valves before turning off fuel oil to premises or piping section.
- B. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.4 INSTALLATION OF FUEL-OIL PUMPS

- A. Submersible Fuel-Oil Storage Tank Pumps:
 - 1. Suspend pumps from supply piping and anchor to bottom of tank.
- B. Simplex and Multiplex Fuel-Oil Pumps:
 - 1. Install pumps with access space for periodic maintenance including removal of motors, impellers, and accessories.
 - 2. Set pumps on and anchor to concrete base.
 - 3. Pump Mounting:
 - a. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - b. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - c. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
 - 4. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and **[elastomeric hangers][spring hangers][spring hangers with vertical-limit stop]** of size required to support weight of in-line pumps.
 - a. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - b. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- C. Install two-piece, full-port ball valves at suction and discharge of pumps. Comply with requirements in

Section 230523.12 "Ball Valves for HVAC Piping."

- D. Install mechanical leak-detector valves at pump discharge.
- E. Install **[Y-pattern][basket][T-pattern]** strainer on inlet side of all fuel-oil pumps.
- F. Install check valve on discharge of all fuel-oil pumps unless provided with built-in check valve.
- G. Install suction piping with minimum fittings and change of direction.
- H. Install vacuum and pressure gauge, upstream and downstream, respectively, at each pump to measure the differential pressure across the pump. Pressure gauges are specified in Section 230500 "Common Work Results for HVAC."

3.5 INSTALLATION OF FUEL-OIL POLISHING SYSTEMS

- A. Polishing System Mounting:
 - 1. Install equipment cabinet on cast-in-place concrete equipment base. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Install suction line, with foot valve, at one end of storage tank, **1 inch (25 mm)** from the bottom of tank.
- C. Install return line at the opposite end of storage tank from suction line.

3.6 LABELING AND IDENTIFYING

- A. Install nameplates and signs on each fuel-oil pump. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to **[support][supervise]** field tests and inspections.
- C. Tests and Inspections:
 - 1. Start fuel-oil transfer pumps **[and fuel-oil polishing system pumps]** to verify for proper operation of pump, and check for leaks.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Fuel-oil pumps **[and fuel-oil polishing systems]** will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



3.8 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train] Owner's maintenance personnel to adjust, operate, and maintain [fuel-oil pumps][and fuel-oil polishing system]<Insert other>.**

END OF SECTION 23 12 13 00



SECTION 23 13 13 00 - FACILITY UNDERGROUND FUEL-OIL STORAGE TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Underground fuel-oil storage tanks, double-wall steel, with STI-P3.
2. Underground fuel-oil storage tanks, composite, double-wall steel.
3. Underground fuel-oil storage tanks, double wall, jacketed, steel.
4. Underground fuel-oil storage tanks, double-wall FRP.
5. Underground fuel-oil storage tank accessories.
6. Fuel-oil-level gauge system.
7. Fuel-oil leak-detection and monitoring system.
8. Fuel oil.
9. Manholes, concrete.
10. Labels and identification.

1.2 DEFINITIONS

- A. FPM:** Vinylidene fluoride-hexafluoropropylene copolymer rubber.
- B. FRP:** Glass-fiber-reinforced plastic.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, and dimensions of individual components and profiles.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Fuel-oil storage tank accessories.
4. Fuel-oil leak-detection and monitoring system.

B. Shop Drawings: For underground fuel-oil storage tanks.

1. Include plans, elevations, sections, concrete ballast pads and anchors, and lifting or supporting points.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Shop Drawing Scale: [1/4 inch per foot (1:50)]<Insert scale>.

1.4 INFORMATIONAL SUBMITTALS

- A. Site Survey:** Plans, drawn to scale, on which underground fuel-oil storage tanks are indicated and coordinated with other services and utilities.



- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-oil equipment and accessories.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: For FRP tanks, installers are to be trained and certified by tank manufacturer.
- B. EPA Compliance: Comply with requirements of the EPA and of state and local authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as indicated on Shop Drawings. Do not move or lift tanks unless empty.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of fuel-oil storage tanks that fail in materials or workmanship within specified warranty period.

1. Storage Tanks:

- a. Failures include, but are not limited to, the following when used for storage of fuel oil at temperatures not exceeding **[150 deg F (66 deg C)]<Insert temperature>**:
 - 1) Structural failures including cracking, breakup, and collapse.
 - 2) Corrosion failure including external and internal corrosion of steel tanks.
- b. Warranty Period: **[30]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 UNDERGROUND FUEL-OIL STORAGE TANKS, DOUBLE-WALL STEEL, WITH STI-P3

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Hall Tank Co]**
 - 2. **[Hamilton Tanks]**
 - 3. **[Highland Tank & Manufacturing Company, Inc.]**
 - 4. **[Kennedy Tank and Manufacturing Company, Inc.]**
 - 5. **[Modern Welding Company, Inc.]**



6. [Palmer Manufacturing and Tank Company]
 7. [Steel Tank and Fabricating Corporation (STAFCO)]
 8. [Watco Tanks, Inc]
 9. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Hall Tank Co]
 2. [Hamilton Tanks]
 3. [Highland Tank & Manufacturing Company, Inc.]
 4. [Kennedy Tank and Manufacturing Company, Inc.]
 5. [Modern Welding Company, Inc.]
 6. [Palmer Manufacturing and Tank Company]
 7. [Steel Tank and Fabricating Corporation (STAFCO)]
 8. [Watco Tanks, Inc]
 9. <Insert manufacturer's name>
- C. Source Limitations: Obtain double-wall, steel, STI-P3 underground fuel-oil storage tanks from single manufacturer.
- D. Description: UL 58 and STI-P3, double-wall, horizontal steel tank; with cathodic protection and electrical isolation.
1. Containment Method: STI-P3, [Type I, with primary and secondary walls in contact][Type II, with interstitial space].
- E. Construction: Fabricated with welded carbon steel; suitable for operation at atmospheric pressure and for storing liquids with specific gravity up to 1.1; fabricated for the following loads:
1. Depth of Bury: **36 inches (900 mm)** from top of tank to finished surface.
 2. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
 3. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of **32,000 lb (14 515 kg)**.
- F. Corrosion-Protection System: Protect tank and factory-installed piping by engineered and installed corrosion-protection system in accordance with STI-P3, with means of monitoring cathodic protection.
- G. Capacities and Characteristics:
1. Capacity: <Insert gal. (L)>.
 2. Diameter: <Insert feet (m)>.
 3. Length: <Insert feet (m)>.
 4. Connection Sizes:
 - a. Fill Line: <Insert NPS (DN)>.
 - b. Vent Line: <Insert NPS (DN)>.
 - c. Outlet: <Insert NPS (DN)>.
 - d. Return: <Insert NPS (DN)>.
 - e. Gauge: <Insert NPS (DN)>.
 5. Manholes:
 - a. Number Required: <Insert number>.
 - b. Diameter: <Insert inches (mm)>.



6. Fuel-Oil Grade Number: **[Grade No. 1][Grade No. 2][Diesel][Low-Sulfur Diesel][Ultra-Low Sulfur Diesel]<Insert grade>**.

2.2 UNDERGROUND FUEL-OIL STORAGE TANKS, COMPOSITE, DOUBLE-WALL STEEL

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Hall Tank Co]**
2. **[Hamilton Tanks]**
3. **[Lannon Tank Corporation]**
4. **[Modern Welding Company, Inc.]**
5. **[Palmer Manufacturing and Tank Company]**
6. **[Watco Tanks, Inc]**
7. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Hall Tank Co]**
2. **[Hamilton Tanks]**
3. **[Lannon Tank Corporation]**
4. **[Modern Welding Company, Inc.]**
5. **[Palmer Manufacturing and Tank Company]**
6. **[Watco Tanks, Inc]**
7. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain double-wall, steel, composite underground fuel-oil storage tanks from single manufacturer.

- D. Description: UL 58, double-wall, horizontal, composite tank; with FRP or urethane coating complying with UL 1746 and STI F894.

1. Containment Method: STI F894, **[Type I, with primary and secondary walls in contact][Type II, with interstitial space]**.

- E. Construction: Fabricated with welded carbon steel and factory FRP or urethane coating in accordance with UL 1746 and STI F894; suitable for operation at atmospheric pressure and for storing liquids with specific gravity up to 1.1; fabricated for the following loads:

1. Depth of Bury: **36 inches (900 mm)** from top of tank to finished surface.
2. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
3. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of **32,000 lb (14 515 kg)**.

- F. Capacities and Characteristics:

1. Capacity: **<Insert gal. (L)>**.
2. Diameter: **<Insert feet (m)>**.
3. Length: **<Insert feet (m)>**.
4. Connection Sizes:

- a. Fill Line: **<Insert NPS (DN)>**.
 - b. Vent Line: **<Insert NPS (DN)>**.
 - c. Outlet: **<Insert NPS (DN)>**.
 - d. Return: **<Insert NPS (DN)>**.
 - e. Gauge: **<Insert NPS (DN)>**.
5. Manholes:
- a. Number Required: **<Insert number>**.
 - b. Diameter: **<Insert inches (mm)>**.
6. Fuel-Oil Grade Number: **[Grade No. 1][Grade No. 2][Diesel][Low-Sulfur Diesel][Ultra-Low Sulfur Diesel]<Insert grade>**.

2.3 UNDERGROUND FUEL-OIL STORAGE TANKS, DOUBLE WALL, JACKETED, STEEL

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Hall Tank Co]**
2. **[Hamilton Tanks]**
3. **[Highland Tank & Manufacturing Company, Inc.]**
4. **[Kennedy Tank and Manufacturing Company, Inc.]**
5. **[Lannon Tank Corporation]**
6. **[Modern Welding Company, Inc.]**
7. **[Palmer Manufacturing and Tank Company]**
8. **[Watco Tanks, Inc]**
9. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Hall Tank Co]**
2. **[Hamilton Tanks]**
3. **[Highland Tank & Manufacturing Company, Inc.]**
4. **[Kennedy Tank and Manufacturing Company, Inc.]**
5. **[Lannon Tank Corporation]**
6. **[Modern Welding Company, Inc.]**
7. **[Palmer Manufacturing and Tank Company]**
8. **[Watco Tanks, Inc]**
9. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain double-wall, jacketed, steel underground fuel-oil storage tanks from single manufacturer.

- D. Description: Double-wall, jacketed, horizontal steel tank; complying with UL 58, and with plastic or fiberglass jacket and corrosion-protection system in accordance with UL 1746 **[and STI F922]**.

- E. Construction: Tank fabricated with welded carbon steel, and jacket fabricated with plastic or fiberglass and vacuum-sealed interstitial space; suitable for operation at atmospheric pressure and with integral leak-detection device. Tank fabricated for the following loads:

1. Depth of Bury: **36 inches (900 mm)** from top of tank to finished surface.
2. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is



fully flooded.

3. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of **32,000 lb (14 515 kg)**.

F. Capacities and Characteristics:

1. Capacity: **<Insert gal. (L)>**.
2. Diameter: **<Insert feet (m)>**.
3. Length: **<Insert feet (m)>**.
4. Connection Sizes:
 - a. Fill Line: **<Insert NPS (DN)>**.
 - b. Vent Line: **<Insert NPS (DN)>**.
 - c. Outlet: **<Insert NPS (DN)>**.
 - d. Return: **<Insert NPS (DN)>**.
 - e. Gauge: **<Insert NPS (DN)>**.
5. Manholes:
 - a. Number Required: **<Insert number>**.
 - b. Diameter: **<Insert inches (mm)>**.
6. Fuel-Oil Grade Number: **[Grade No. 1][Grade No. 2][Diesel][Low-Sulfur Diesel][Ultra-Low Sulfur Diesel]<Insert grade>**.

2.4 UNDERGROUND FUEL-OIL STORAGE TANKS, DOUBLE-WALL FRP

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Containment Solutions, Inc]**
 2. **[Palmer Manufacturing and Tank Company]**
 3. **[Xerxes by Shawcor Ltd.]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Containment Solutions, Inc]**
 2. **[Palmer Manufacturing and Tank Company]**
 3. **[Xerxes by Shawcor Ltd.]**
 4. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain double-wall, FRP underground fuel-oil storage tanks from single manufacturer.
- D. Description: Horizontal, FRP underground fuel-oil storage tank; UL 1316, double wall, with interstitial space **[and integral, hydrostatic, leak-detection and monitoring system]**.
- E. Construction: Fabricated with fiberglass-reinforced polyester resins; suitable for operation at atmospheric pressure; fabricated for the following loads:

1. Depth of Bury: **36 inches (900 mm)** from top of tank to finished surface.
2. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
3. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of **32,000 lb (14 515 kg)**.

F. Capacities and Characteristics:

1. Capacity: **<Insert gal. (L)>**.
2. Diameter: **<Insert feet (m)>**.
3. Length: **<Insert feet (m)>**.
4. Connection Sizes:
 - a. Fill Line: **<Insert NPS (DN)>**.
 - b. Vent Line: **<Insert NPS (DN)>**.
 - c. Outlet: **<Insert NPS (DN)>**.
 - d. Return: **<Insert NPS (DN)>**.
 - e. Gauge: **<Insert NPS (DN)>**.
5. Manholes:
 - a. Number Required: **<Insert number>**.
 - b. Diameter: **<Insert inches (mm)>**.
6. Fuel-Oil Grade Number: **[Grade No. 1][Grade No. 2][Diesel][Low-Sulfur Diesel][Ultra-Low Sulfur Diesel]<Insert grade>**.

2.5 UNDERGROUND FUEL-OIL STORAGE TANK ACCESSORIES

- A. Tank Manholes: **22-inch- (560-mm-)** minimum diameter; bolted, flanged, and gasketed, with extension collar; for access to inside of tank.
- B. Steel Tank Masonry Supports: Two **[6-by-6-by-3/8-inch (150-by-150-by-10-mm)]<Insert dimensions>** steel angles, **[72 inches (1800 mm)]<Insert dimension>** long, located longitudinally on tank on each side of manholes and continuously welded in place.
- C. Threaded pipe connection fittings on top of tank for fill, supply, return, vent, sounding, and gauging; in locations and of sizes indicated. Include cast-iron plugs for shipping.
- D. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gauge, and other tube openings.
- E. Lifting Lugs: For handling and installation.
- F. Ladders: Carbon-steel ladder inside tank, anchored to top and bottom. Include reinforcement of tank at bottom of ladder.
- G. Supply Tube: Extension of supply piping fitting into tank, terminating **6 inches (150 mm)** above tank bottom and cut at a **45-degree angle- (1:1 slope)**.
- H. Sounding and Gauge Tubes: Extension of fitting into tank, terminating **6 inches (150 mm)** above tank bottom and cut at a **45-degree angle (1:1 slope)**.
- I. Containment Sumps: **[Fiberglass][PE]** with sump base, add-on extension pieces as required, sump top, lid, and gasket-seal joints. Include sump entry boots for pipe penetrations through sidewalls.

- J. Sump Entry Boots: Two-part pipe fitting for field assembly and of size required to fit over pipe. Include gaskets shaped to fit sump sidewall, sleeves, seals, and clamps as required for liquid-tight pipe penetrations.
- K. Anchor Straps: Storage tank manufacturer's standard anchoring system, with straps, strap-insulating material, cables, and turnbuckles; of strength at least one-and-one-half times maximum uplift force of empty tank without backfill in place.
- L. Filter Mat: Geotextile woven or spun filter fabric, in 1 or more layers, for minimum total weight of [3 oz./sq. yd. (101.7 g/sq. m)]<Insert dimension>.
- M. Overfill Prevention Valves: Factory fabricated or shop or field assembled from manufacturer's standard components. Include drop tube, cap, fill nozzle adaptor, check valve mechanism or other devices, and vent if required to restrict flow at 95 percent of tank capacity and to provide complete shutoff of filling at [98][99]<Insert number> percent of tank capacity.

2.6 FUEL-OIL-LEVEL GAUGE SYSTEM

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- 1. [Caldwell Systems Corporation]
- 2. [Clawson Tank Company]
- 3. [Franklin Fueling Systems]
- 4. [Gems Sensors & Controls Inc.]
- 5. [Highland Tank & Manufacturing Company, Inc.]
- 6. [In-Situ, Inc]
- 7. [King Engineering Corp]
- 8. [Krueger Sentry Gauge]
- 9. [Pneumercator Inc]
- 10. [Preferred Utilities Manufacturing Corporation]
- 11. [Rochester Sensors]
- 12. [Tuthill Corporation]
- 13. [Uehling Instrument Company]
- 14. [Venture Measurement Company, LLC]
- 15. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1. [Caldwell Systems Corporation]
- 2. [Clawson Tank Company]
- 3. [Franklin Fueling Systems]
- 4. [Gems Sensors & Controls Inc.]
- 5. [Highland Tank & Manufacturing Company, Inc.]
- 6. [In-Situ, Inc]
- 7. [King Engineering Corp]
- 8. [Krueger Sentry Gauge]
- 9. [Pneumercator Inc]
- 10. [Preferred Utilities Manufacturing Corporation]
- 11. [Rochester Sensors]
- 12. [Tuthill Corporation]
- 13. [Uehling Instrument Company]

14. **[Venture Measurement Company, LLC]**
15. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain fuel-oil-level gauge system from single manufacturer.
- D. Description: Calibrated, fuel-oil-level gauge system complying with **[UL 180 with floats][UL 1238 with probes]** or other sensors and remote annunciator panel.
- E. Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in **gallons (liters)**, and overfill alarm. Include gauge volume range that covers fuel-oil storage capacity.
- F. Controls: Electrical, operating on **[120]<Insert voltage> V ac.**

2.7 FUEL-OIL LEAK-DETECTION AND MONITORING SYSTEM

- A. Fuel-Oil Leak-Detection and Monitoring, Cable and Sensor System: Comply with UL 1238.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Caldwell Systems Corporation]**
 - b. **[Containment Solutions, Inc]**
 - c. **[Franklin Fueling Systems]**
 - d. **[Gems Sensors & Controls Inc.]**
 - e. **[Highland Tank & Manufacturing Company, Inc.]**
 - f. **[In-Situ, Inc]**
 - g. **[PermAlert]**
 - h. **[Pneumercator Inc]**
 - i. **[Veeder-Root Company (The)]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Caldwell Systems Corporation]**
 - b. **[Containment Solutions, Inc]**
 - c. **[Franklin Fueling Systems]**
 - d. **[Gems Sensors & Controls Inc.]**
 - e. **[Highland Tank & Manufacturing Company, Inc.]**
 - f. **[In-Situ, Inc]**
 - g. **[PermAlert]**
 - h. **[Pneumercator Inc]**
 - i. **[Veeder-Root Company (The)]**
 - j. **<Insert manufacturer's name>**
3. Source Limitations: Obtain cable and sensor fuel-oil leak-detection and monitoring system from single manufacturer.
4. Calibrated fuel-oil leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil storage tanks and fuel-oil piping.
5. Include fittings and devices required for testing.
6. Controls: Electrical, operating on **[120]<Insert voltage> V ac.**

7. Calibrated fuel-oil-level gauge complying with **[UL 180 with floats][UL 1238 with probes]** or other sensors and remote annunciator panel.
8. Remote annunciator panel with visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in **gallons (liters)**, and overfill alarm. Include gauge volume range that covers fuel-oil storage capacity.
9. Remote Annunciator Panel Controls: Electrical, operating on **[120]<Insert voltage> V ac.**

B. Fuel-Oil Leak Detection and Monitoring, Hydrostatic System: Comply with UL 1238.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Caldwell Systems Corporation]**
 - b. **[Containment Solutions, Inc]**
 - c. **[Franklin Fueling Systems]**
 - d. **[Gems Sensors & Controls Inc.]**
 - e. **[Highland Tank & Manufacturing Company, Inc.]**
 - f. **[In-Situ, Inc]**
 - g. **[PermAlert]**
 - h. **[Pneumercator Inc]**
 - i. **[Veeder-Root Company (The)]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Caldwell Systems Corporation]**
 - b. **[Containment Solutions, Inc]**
 - c. **[Franklin Fueling Systems]**
 - d. **[Gems Sensors & Controls Inc.]**
 - e. **[Highland Tank & Manufacturing Company, Inc.]**
 - f. **[In-Situ, Inc]**
 - g. **[PermAlert]**
 - h. **[Pneumercator Inc]**
 - i. **[Veeder-Root Company (The)]**
 - j. **<Insert manufacturer's name>**
3. Source Limitations: Obtain hydrostatic fuel-oil leak-detection and monitoring system from single manufacturer.
4. Calibrated fuel-oil leak-detection and monitoring system with brine antifreeze solution, reservoir sensor, and electronic control panel to monitor leaks in inner and outer tank walls.
5. Include fittings and devices required for testing.
6. Controls: Electrical, operating on **[120]<Insert voltage> V ac.**
7. Calibrated fuel-oil-level gauge complying with **[UL 180 with floats][UL 1238 with probes]** or other sensors and remote annunciator panel.
8. Remote annunciator panel with visual and audible, high-tank-level and low-tank-level alarms; fuel indicator with registration in **gallons (liters)**, and overfill alarm. Include gauge volume range that covers fuel-oil storage capacity.
9. Remote Annunciator Panel Controls: Electrical, operating on **[120]<Insert voltage> V ac.**

2.8 FUEL OIL

- A. Fuel Oil: ASTM D396, [Grade No. 1][Grade No. 2].
- B. Diesel Fuel Oil: ASTM D975, [Grade Low Sulfur][Grade Ultra-Low Diesel][Grade No. 1-D, special purpose][Grade No. 2-D, general purpose], high volatility.

2.9 MANHOLES, CONCRETE

- A. Precast Concrete Manhole Sections: ASTM C478/C478M, base and [concentric-cone][eccentric-cone] sections with integral ladder or steps.
- B. Cast-Iron Frame and Cover: Heavy-duty, water-resistant, cast-iron manhole frame, gasket, and bolted cover; [24-inch- (609-mm-)]<Insert dimension> diameter, inside opening dimension; [8-inch (203-mm)]<Insert dimension> frame riser height.

2.10 LABELS AND IDENTIFICATION

- A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of **6 inches (152 mm)** wide and **4 mils (0.1 mm)** thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to **30 inches (762 mm)** deep; colored yellow.

2.11 SOURCE QUALITY CONTROL

- A. Pressure test and inspect fuel-oil storage tanks, after fabrication and before shipment, in accordance with ASME and the following:
 - 1. Horizontal, Steel, Underground Fuel-Oil Storage Tanks with the STI-P3 Corrosion-Protection System: UL 58 and STI-P3.
 - 2. Composite, Steel, Underground Fuel-Oil Storage Tanks: UL 58.
 - 3. Composite and Jacketed, Steel, Underground Fuel-Oil Storage Tanks: UL 58.
 - 4. Jacketed, Steel, Underground Fuel-Oil Storage Tanks: UL 58.
 - 5. FRP Underground Fuel-Oil Storage Tanks: UL 1316.
- B. Affix standards organization's code stamp.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for underground fuel-oil storage tanks to verify actual locations.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

- B. Excavate to sufficient depth for a minimum of **36 inches (900 mm)** of earth cover from top of tank to finished grade. Allow for cast-in-place, concrete-ballast base plus **6 inches (150 mm)** of sand or pea gravel between ballast base and tank. Extend excavation at least **12 inches (300 mm)** around perimeter of tank.
- C. Backfill excavation with clean sand or pea gravel in **12-inch (305-mm)** lifts and tamp backfill lift to consolidate.
- D. Install filter mat between top of backfill material and earth fill.

3.3 INSTALLATION OF UNDERGROUND FUEL-OIL STORAGE TANK

- A. Install tank in accordance with NFPA 30 and 31 by a contractor trained and certified by tank manufacturer.
- B. Set tie-down eyelets for hold-down straps in concrete-ballast base and tie to reinforcing steel.
- C. Place **6 inches (152 mm)** of clean sand or pea gravel on top of concrete-ballast base.
- D. Set tank on fill materials and install hold-down straps.
- E. Connect piping.
- F. Install tank leak-detection and monitoring devices.
- G. Install containment sumps.
- H. Install steel underground fuel-oil storage tank with the STI-P3 corrosion-protection system in accordance with STI R821 and STI R891. Protect anodes during tank placement and backfilling operations.
- I. Install composite, steel, underground fuel-oil storage tank in accordance with STI R913 and STI R891.
- J. Install jacketed, steel, underground fuel-oil storage tank in accordance with STI R923 and STI R891.
- K. Install FRP underground fuel-oil storage tank with FRP hold-down straps, manhole extensions, and manhole risers.
- L. Fill storage tank with specified fuel oil.

3.4 INSTALLATION OF LIQUID-LEVEL GAUGE SYSTEM

- A. Install liquid-level gauge system. Install panel inside building at location indicated on Drawings.

3.5 INSTALLATION OF FUEL-OIL LEAK-DETECTION AND MONITORING SYSTEM

- A. Install fuel-oil leak-detection and monitoring system. Install alarm panel inside building at location indicated.
 - 1. Double-Wall, Fuel-Oil Storage Tanks: **[Install probes][Install probes or use factory-installed integral probes][Use factory-installed integral probes]** in interstitial space.

2. Single-Wall, Fuel-Oil Storage Tanks: Install probes as indicated on Drawings.
3. Double-Containment, Fuel-Oil Piping: Install fuel-oil leak-detection sensor **[probes in fuel-oil storage tank containment sumps and at low points in piping][cable probes in interstitial space of double-containment piping]**.
4. Install liquid-level gauge.

3.6 LABELING AND IDENTIFYING

- A. Nameplates, pipe identification, and signs are specified in Section 230553 "Identification for HVAC Piping and Equipment."
- B. Install detectable warning tape directly above underground fuel-oil storage tank, **[12 inches (304 mm)]<Insert dimension>** below finished grade, except **[6 inches (152 mm)]<Insert dimension>** below subgrade under pavements and slabs.
 1. Terminate tracer wire in an accessible area and identify as "tracer wire" for future use with plastic-laminate sign.
 2. Install over edges of each underground fuel-oil storage tank.

3.7 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 1. Tanks: Minimum hydrostatic or compressed-air test pressures for fuel-oil storage tanks that have not been factory tested and do not bear the ASME code stamp or a listing mark acceptable to authorities having jurisdiction:
 - a. Double-Wall Tanks:
 - 1) Inner Tanks: Minimum **[3 psig (20.7 kPa)]<Insert pressure>** and maximum **[5 psig (34.5 kPa)]<Insert pressure>**.
 - 2) Interstitial Space: Minimum **[3 psig (20.7 kPa)]<Insert pressure>** and maximum **[5 psig (34.5 kPa)]<Insert pressure>**, or **[5.3 in. Hg (18 kPa)]<Insert negative pressure>** vacuum.
 - b. Where vertical height of fill and vent pipes is such that the static head imposed on the bottom of the tank is greater than **10 psig (69 kPa)**, hydrostatically test the tank and fill and vent pipes to a pressure equal to the static head thus imposed.
 - c. Maintain the test pressure for one hour.
- C. Underground fuel-oil storage tanks will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 23 13 13 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 13 13 13	22 12 23 26	Facility Fuel-Oil Piping
23 13 13 13	23 11 26 00	Facility Liquefied-Petroleum Gas Piping
23 13 13 13	23 13 13 00	Facility Underground Fuel-Oil Storage Tanks
23 13 13 23	22 12 23 26	Facility Fuel-Oil Piping
23 13 13 23	23 13 13 00	Facility Underground Fuel-Oil Storage Tanks



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 13 23 00 - FACILITY ABOVEGROUND FUEL-OIL STORAGE TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Aboveground fuel-oil storage tanks, vertical, steel.
2. Aboveground fuel-oil storage tanks, horizontal, steel.
3. Aboveground fuel-oil storage tanks, steel, with containment dike.
4. Aboveground fuel-oil storage tanks, insulated, steel.
5. Aboveground fuel-oil storage tanks, steel, with concrete vault.
6. Aboveground fuel-oil storage tank, shop painting.
7. Aboveground fuel-oil storage tank accessories.
8. Fuel-oil-level gauge system.
9. Fuel-oil leak-detection and monitoring systems.
10. Fuel oil.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, and dimensions of individual components and profiles.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Fuel-oil storage tank accessories.
4. Fuel-oil leak-detection and monitoring system.

B. Shop Drawings: For aboveground fuel-oil storage tanks.

1. Include plans, elevations, sections, concrete bases, anchors, and lifting or supporting points.
2. Indicate details of equipment assemblies. Indicate dimensions, components, and location and size of each field connection.
3. Shop Drawing Scale: **[1/4 inch per foot (1:50)]<Insert scale>**.

1.3 INFORMATIONAL SUBMITTALS

A. Site Survey: Plans, drawn to scale, on which fuel-oil storage tanks are indicated and coordinated with other services and utilities.

Retain "Seismic Qualification Data" Paragraph below if required by seismic criteria applicable to Project. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC." See ASCE/SEI 7 for certification requirements for equipment and components.

B. Seismic Qualification Data: Certificates for aboveground fuel oil storage tanks, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of



- assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

Retain "Welding certificates" Paragraph below if retaining procedures for welder certification in "Quality Assurance" Article.

- C. Welding certificates.

Retain "Field quality-control reports" Paragraph below if Contractor is responsible for field quality-control testing and inspecting.

- D. Field quality-control reports.
- E. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-oil equipment and accessories to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

EPA Compliance: Comply with requirements of the EPA and of state and local authorities having jurisdiction. Retain "Steel Support Welding Qualifications" Paragraph for welded supports. Also retain "Welding certificates" Paragraph in "Informational Submittals" Article.

- A. Steel Support Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as shown on Shop Drawings. Do not move or lift tanks unless empty.

1.7 WARRANTY

When warranties are required, verify with Owner's counsel that warranties stated in this article are not less than remedies available to Owner under prevailing local laws.

- A. Special Warranty: Manufacturer agrees to repair or replace components of fuel-oil storage tanks that fail in materials or workmanship within specified warranty period.

1. Storage Tanks:
 - a. Failures include, but are not limited to, the following when used for storage of fuel oil at temperatures not exceeding [150 deg F (66 deg C)]<Insert temperature>:

- 1) Structural failures including cracking, breakup, and collapse.

Retain first subparagraph below for steel tanks.

- 2) Corrosion failure including external and internal corrosion of steel tanks.

Verify available warranties and warranty periods for units and components with manufacturers listed in Part 2 articles.

- b. Warranty Period: **[30]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

Retain "Delegated Design" Paragraph below if Contractor is required to assume responsibility for design.

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design restraint and anchors for aboveground fuel-oil storage tanks and equipment, including comprehensive engineering analysis, using performance requirements and design criteria indicated.

Retain "Seismic Performance" Paragraph below with "Seismic Qualification Data" Paragraph in "Informational Submittals" Article for projects requiring seismic design. Delete paragraph if performance requirements are indicated on Drawings. Model building codes and ASCE/SEI 7 establish criteria for buildings subject to earthquake motions. Coordinate requirements with structural engineer.

- B. Seismic Performance: Factory-installed support attachments for aboveground fuel-oil storage tanks are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.

Retain first subparagraph below to define the term "withstand" as it applies to this Project. Definition varies with type of building and occupancy and is critical to valid certification. Option is used for essential facilities where equipment must operate immediately after an earthquake.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."

For life-safety components required to function after an earthquake (such as fire-sprinkler systems, components that contain hazardous content, system components serving critical healthcare functions, and storage racks in structures open to the public), the Component Importance Factor is 1.5. For other components, the Component Importance Factor is 1.0 unless the structure is in Seismic Use Group III and component is necessary for continued operation of facility or failure of component could impair continued operation of facility, in which case the Component Importance Factor is 1.5.

2. Component Importance Factor: **[1.5][1.0]**.

Retain "Wind Performance" Paragraph below with "Product Certificates" Paragraph in "Informational Submittals" Article for project requiring wind-restraint design. Delete paragraph if performance requirements are indicated on Drawings. Model building codes and ASCE/SEI 7 establish criteria for building equipment subject to wind effects. Coordinate requirements with structural engineer.



- C. Wind Performance: Aboveground fuel-oil storage tanks are to withstand the effects of wind determined in accordance with [ASCE/SEI 7]<Insert requirement>. See [Section 230548 "Vibration and Seismic Controls for HVAC"]<Section 230548.13 "Vibration Controls for HVAC">].

2.2 ABOVEGROUND FUEL-OIL STORAGE TANKS, VERTICAL, STEEL

Retain "Manufacturers" Paragraph and list of manufacturers below to require products from manufacturers listed or a comparable product from other manufacturers.

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [Brown Tank, LLC]
 2. [Buffalo Tank Company, Inc]
 3. [Hall Tank Co]
 4. [Hamilton Tanks]
 5. [Highland Tank & Manufacturing Company, Inc.]
 6. [Modern Welding Company, Inc.]
 7. [Palmer Manufacturing and Tank Company]
 8. [Steel Tank and Fabricating Corporation (STAFCO)]
 9. [Watco Tanks, Inc]
 10. [We-Mac Manufacturing, Inc.]
 11. <Insert manufacturer's name>

Retain "Basis-of-Design Product" Paragraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Brown Tank, LLC]
 2. [Buffalo Tank Company, Inc]
 3. [Hall Tank Co]
 4. [Hamilton Tanks]
 5. [Highland Tank & Manufacturing Company, Inc.]
 6. [Modern Welding Company, Inc.]
 7. [Palmer Manufacturing and Tank Company]
 8. [Steel Tank and Fabricating Corporation (STAFCO)]
 9. [Watco Tanks, Inc]
 10. [We-Mac Manufacturing, Inc.]
 11. <Insert manufacturer's name>

- C. Source Limitations: Obtain vertical, steel, aboveground fuel-oil storage tanks from single manufacturer.

- D. Description:

Retain one of two subparagraphs below. Double-wall tanks may be required if tanks are not diked. Dikes may be required when single-wall tanks are used. Consult applicable codes and authorities having jurisdiction. If retaining both single-wall and double-wall tanks, include drawing designation for each type of tank.

1. UL 142, single-wall, vertical steel tank.

Not all manufacturers are members of the Steel Tank Institute and therefore may not use the STI F921



designation. Retaining the option below will restrict tank products to STI member manufacturers. Consult manufacturers.

2. UL 142[**and STI F921**], double-wall, vertical steel tank; with primary- and secondary-containment walls and interstitial space.
- E. Construction: Fabricated with welded carbon steel suitable for operation at atmospheric pressure, for storing fuel oil with specific gravity up to 1.1, and for maintained temperature up to **150 deg F (66 deg C)**.

If Project has more than one type or configuration of vertical, steel, aboveground fuel-oil storage tanks, delete "Capacities and Characteristics" Paragraph below and schedule tanks on Drawings.

- F. Capacities and Characteristics:
 1. Capacity: **<Insert gal. (L)>**.
 2. Diameter: **<Insert feet (m)>**.
 3. Length: **<Insert feet (m)>**.
 4. Connection Sizes:
 - a. Fill Line: **<Insert NPS (DN)>**.
 - b. Vent Line: **<Insert NPS (DN)>**.
 - c. Outlet: **<Insert NPS (DN)>**.
 - d. Return: **<Insert NPS (DN)>**.
 - e. Gauge: **<Insert NPS (DN)>**.
 5. Manholes:
 - a. Number Required: **<Insert number>**.
 - b. Diameter: **<Insert inches (mm)>**.
 6. Fuel: **[Fuel oil][Diesel]**.

2.3 ABOVEGROUND FUEL-OIL STORAGE TANKS, HORIZONTAL, STEEL

Retain "Manufacturers" Paragraph and list of manufacturers below to require products from manufacturers listed or a comparable product from other manufacturers.

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Brown Tank, LLC]**
 2. **[Buffalo Tank Company, Inc]**
 3. **[Hall Tank Co]**
 4. **[Hamilton Tanks]**
 5. **[Highland Tank & Manufacturing Company, Inc.]**
 6. **[Modern Welding Company, Inc.]**
 7. **[Palmer Manufacturing and Tank Company]**
 8. **[Safe-T-Tank Corp]**
 9. **[Steel Tank and Fabricating Corporation (STAFCO)]**
 10. **[Watco Tanks, Inc]**
 11. **[We-Mac Manufacturing, Inc.]**
 12. **<Insert manufacturer's name>**



Retain "Basis-of-Design Product" Paragraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Brown Tank, LLC]**
2. **[Buffalo Tank Company, Inc]**
3. **[Hall Tank Co]**
4. **[Hamilton Tanks]**
5. **[Highland Tank & Manufacturing Company, Inc.]**
6. **[Modern Welding Company, Inc.]**
7. **[Palmer Manufacturing and Tank Company]**
8. **[Safe-T-Tank Corp]**
9. **[Steel Tank and Fabricating Corporation (STAFCO)]**
10. **[Watco Tanks, Inc]**
11. **[We-Mac Manufacturing, Inc.]**
12. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain horizontal, steel, aboveground fuel-oil storage tanks from single manufacturer.

- D. Description:

Retain one of two subparagraphs below. Double-wall tanks may be required if tanks are not diked. Dikes may be required when single-wall tanks are used. Consult applicable codes and authorities having jurisdiction. If retaining both single-wall and double-wall tanks, include drawing designation for each type of tank.

1. UL 142, single-wall, horizontal steel tank.

Not all manufacturers are members of the Steel Tank Institute and therefore may not use the STI F921 designation. Retaining the option below will restrict tank products to STI member manufacturers. Consult manufacturers.

2. UL 142[**and STI F921**], double-wall, horizontal steel tank; with primary- and secondary-containment walls and interstitial space.

- E. Construction: Fabricated with welded carbon steel; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with maintained temperature up to **150 deg F (66 deg C)**.

- F. Supports:

Retain one of first two subparagraphs below.

1. Manufacturer's standard structural steel welded to tank.
2. Manufacturer's standard type[**and number**], steel or cast-iron cradles, for field installation.
3. Number of Supports: **<Insert number>**.

Concrete or steel supports for off-the-ground mounting must be specified or detailed on Drawings.

If Project has more than one type or configuration of horizontal, steel, aboveground fuel-oil storage tanks, delete "Capacities and Characteristics" Paragraph below and schedule tanks on Drawings.

- G. Capacities and Characteristics:



1. Capacity: <Insert gal. (L)>.
2. Diameter: <Insert feet (m)>.
3. Length: <Insert feet (m)>.
4. Connection Sizes:
 - a. Fill Line: <Insert NPS (DN)>.
 - b. Vent Line: <Insert NPS (DN)>.
 - c. Outlet: <Insert NPS (DN)>.
 - d. Return: <Insert NPS (DN)>.
 - e. Gauge: <Insert NPS (DN)>.
5. Manholes:
 - a. Number Required: <Insert number>.
 - b. Diameter: <Insert inches (mm)>.
6. Fuel: [Fuel il][Diesel].

2.4 ABOVEGROUND FUEL-OIL STORAGE TANKS, HORIZONTAL, STEEL, WITH CONTAINMENT DIKE

Retain "Manufacturers" Paragraph and list of manufacturers below to require products from manufacturers listed or a comparable product from other manufacturers.

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [Areo Power Tanks, LLC]
 2. [Buffalo Tank Company, Inc]
 3. [Hall Tank Co]
 4. [Hamilton Tanks]
 5. [Highland Tank & Manufacturing Company, Inc.]
 6. [Kennedy Tank and Manufacturing Company, Inc.]
 7. [Modern Welding Company, Inc.]
 8. [Watco Tanks, Inc]
 9. [We-Mac Manufacturing, Inc.]
 10. <Insert manufacturer's name>

Retain "Basis-of-Design Product" Paragraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Areo Power Tanks, LLC]
 2. [Buffalo Tank Company, Inc]
 3. [Hall Tank Co]
 4. [Hamilton Tanks]
 5. [Highland Tank & Manufacturing Company, Inc.]
 6. [Kennedy Tank and Manufacturing Company, Inc.]
 7. [Modern Welding Company, Inc.]
 8. [Watco Tanks, Inc]
 9. [We-Mac Manufacturing, Inc.]
 10. <Insert manufacturer's name>



- C. Source Limitations: Obtain horizontal, steel, aboveground fuel-oil storage tanks with containment dike from single manufacturer.

Not all manufacturers are members of the Steel Tank Institute and therefore may not use the STI F911 designation. Retaining the option below will restrict tank products to STI member manufacturers. Consult manufacturers.

- D. Description: UL 142[**and STI F911**], single-wall, horizontal steel tank; with **[open or enclosed][enclosed]** secondary-containment dike with capacity greater than tank capacity.
- E. Construction: Fabricated with welded carbon steel; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with maintained temperature up to **150 deg F (66 deg C)**.

If Project has more than one type or configuration of containment-dike, steel, aboveground fuel-oil storage tanks, delete "Capacities and Characteristics" Paragraph below and schedule tanks on Drawings.

- F. Capacities and Characteristics:
1. Capacity: **<Insert gal. (L)>**.
 2. Diameter: **<Insert feet (m)>**.
 3. Length: **<Insert feet (m)>**.
 4. Connection Sizes:
 - a. Fill Line: **<Insert NPS (DN)>**.
 - b. Vent Line: **<Insert NPS (DN)>**.
 - c. Outlet: **<Insert NPS (DN)>**.
 - d. Return: **<Insert NPS (DN)>**.
 - e. Gauge: **<Insert NPS (DN)>**.
 5. Manholes:
 - a. Number Required: **<Insert number>**.
 - b. Diameter: **<Insert inches (mm)>**.
 6. Fuel: **[Fuel oil][Diesel]**.

2.5 ABOVEGROUND FUEL-OIL STORAGE TANKS, INSULATED, STEEL

Retain "Manufacturers" Paragraph and list of manufacturers below to require products from manufacturers listed or a comparable product from other manufacturers.

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Ace Tank & Fueling Equipment, LLC]**
 2. **[Areo Power Tanks, LLC]**
 3. **[Brown Tank, LLC]**
 4. **[Clark Welding Service]**
 5. **[Hamilton Tanks]**
 6. **[Highland Tank & Manufacturing Company, Inc.]**
 7. **[Modern Welding Company, Inc.]**
 8. **[Steel Tank and Fabricating Corporation (STAFCO)]**



9. **[We-Mac Manufacturing, Inc.]**
10. **<Insert manufacturer's name>**

Retain "Basis-of-Design Product" Paragraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Ace Tank & Fueling Equipment, LLC]**
 2. **[Areo Power Tanks, LLC]**
 3. **[Brown Tank, LLC]**
 4. **[Clark Welding Service]**
 5. **[Hamilton Tanks]**
 6. **[Highland Tank & Manufacturing Company, Inc.]**
 7. **[Modern Welding Company, Inc.]**
 8. **[Steel Tank and Fabricating Corporation (STAFCO)]**
 9. **[We-Mac Manufacturing, Inc.]**
 10. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain insulated, steel, aboveground fuel-oil storage tanks from single manufacturer.

Not all manufacturers are members of the Steel Tank Institute and therefore may not use the STI F941 designation. Retaining the option below will restrict tank products to STI member manufacturers. Consult manufacturers.

- D. Description: **[UL 142 and UL 2085][UL 142, UL 2085, and STI F941]**, thermally insulated and fire resistant as defined in NFPA 30, double-wall, **[horizontal][vertical]** steel tank; with primary- and secondary-containment walls and insulation in the interstitial space.
- E. Construction: Fabricated with welded carbon steel and insulation; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with test temperature in accordance with UL 2085.

If Project has more than one type or configuration of insulated, steel, aboveground fuel-oil storage tanks, delete "Capacities and Characteristics" Paragraph below and schedule tanks on Drawings.

- F. Capacities and Characteristics:
1. Capacity: **<Insert gal. (L)>**.
 2. Diameter: **<Insert feet (m)>**.
 3. Length: **<Insert feet (m)>**.
 4. Connection Sizes:
 - a. Fill Line: **<Insert NPS (DN)>**.
 - b. Vent Line: **<Insert NPS (DN)>**.
 - c. Outlet: **<Insert NPS (DN)>**.
 - d. Return: **<Insert NPS (DN)>**.
 - e. Gauge: **<Insert NPS (DN)>**.
 5. Manholes:
 - a. Number Required: **<Insert number>**.
 - b. Diameter: **<Insert inches (mm)>**.

6. Fuel: **[Fuel oil][Diesel]**.

2.6 ABOVEGROUND FUEL-OIL STORAGE TANKS, STEEL, WITH CONCRETE VAULT

Retain "Manufacturers" Paragraph and list of manufacturers below to require products from manufacturers listed or a comparable product from other manufacturers.

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[ConVault, Inc]**
 2. **[Hall Tank Co]**
 3. **[Hamilton Tanks]**
 4. **[Highland Tank & Manufacturing Company, Inc.]**
 5. **[Modern Welding Company, Inc.]**
 6. **[Palmer Manufacturing and Tank Company]**
 7. **[Steel Tank and Fabricating Corporation (STAFCO)]**
 8. **[Watco Tanks, Inc]**
 9. **[We-Mac Manufacturing, Inc.]**
 10. **<Insert manufacturer's name>**

Retain "Basis-of-Design Product" Paragraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[ConVault, Inc]**
 2. **[Hall Tank Co]**
 3. **[Hamilton Tanks]**
 4. **[Highland Tank & Manufacturing Company, Inc.]**
 5. **[Modern Welding Company, Inc.]**
 6. **[Palmer Manufacturing and Tank Company]**
 7. **[Steel Tank and Fabricating Corporation (STAFCO)]**
 8. **[Watco Tanks, Inc]**
 9. **[We-Mac Manufacturing, Inc.]**
 10. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain steel, aboveground fuel-oil storage tanks with concrete vault from single manufacturer.

Not all manufacturers are members of the Steel Tank Institute and therefore may not use the STI F941 designation. Retaining the option below will restrict tank products to STI member manufacturers. Consult manufacturers.

- D. Description: **[UL 142 and UL 2085][UL 142, UL 2085, and STI F941]**; thermally insulated, fire-resistant and protected, double-wall, horizontal steel tank; with primary- and secondary-containment walls and insulation and with interstitial space.
- E. Construction: Fabricated with welded carbon steel and insulation and encased in concrete that will protect from bullets; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with test temperature in accordance with UL 2085.



If Project has more than one type or configuration of concrete-vaulted, steel, aboveground fuel-oil storage tanks, delete "Capacities and Characteristics" Paragraph below and schedule tanks on Drawings.

F. Capacities and Characteristics:

1. Capacity: **<Insert gal. (L)>**.
2. Diameter: **<Insert feet (m)>**.
3. Length: **<Insert feet (m)>**.
4. Connection Sizes:
 - a. Fill Line: **<Insert NPS (DN)>**.
 - b. Vent Line: **<Insert NPS (DN)>**.
 - c. Outlet: **<Insert NPS (DN)>**.
 - d. Return: **<Insert NPS (DN)>**.
 - e. Gauge: **<Insert NPS (DN)>**.
5. Manholes:
 - a. Number Required: **<Insert number>**.
 - b. Diameter: **<Insert inches (mm)>**.
6. Fuel: **[Fuel oil][Diesel]**.

2.7 ABOVEGROUND FUEL-OIL STORAGE TANK, SHOP PAINTING

Retain only first paragraph below if field painting aboveground fuel-oil storage tank.

- A. Apply manufacturer's standard prime coat to exterior steel surface of aboveground fuel-oil storage tank **and tank supports**.

Retain remainder of this article if shop painting aboveground fuel-oil storage tank.

- B. Prepare exterior steel surface of aboveground fuel-oil storage tank **and tank supports**.

Retain first option in "Shop Cleaning" Paragraph below for "Commercial Blast Cleaning"; retain second option for "Near-White Blast Cleaning."

- C. Shop Cleaning: After fabrication, blast clean in accordance with **[SSPC-SP 6/NACE No. 3][SSPC-SP 10/NACE No. 2]**.
- D. After cleaning, remove dust or residue from cleaned surfaces.
- E. If surface develops rust before prime coat is applied, repeat surface preparation.
- F. Apply manufacturer's standard prime coat to shop-cleaned, dry surface same day as surface preparation.
- G. Apply manufacturer's standard two-component, epoxy finish coats.

2.8 ABOVEGROUND FUEL-OIL STORAGE TANK ACCESSORIES

Show fittings and accessories on plans, details, and piping schematics.

A. Tank Manholes:

Retain one of two subparagraphs below. Retain first subparagraph for horizontal tanks and some vertical tanks; retain second subparagraph for vertical tanks.

1. [22-inch- (560-mm-)]<Insert dimension> minimum diameter; bolted, flanged, and gasketed; centered on top of tank.
2. [22-inch- (560-mm-)]<Insert dimension> minimum diameter; bolted, flanged, and gasketed; on top and at side of tank.

Retain one of first two paragraphs below. Retain first paragraph for horizontal tanks; retain second for vertical tanks.

- B. Threaded pipe connection fittings on top of tank, for fill, supply, return, vent, sounding, and gauging. Include cast-iron plugs for shipping.
- C. Threaded pipe connection fittings on top or sides of tank as indicated, for fill, supply, return, vent, sounding, and gauging. Include cast-iron plugs for shipping.
- D. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gauge, and other tube openings.
- E. Lifting Lugs: For handling and installation.
- F. Ladders:

Retain one of first two subparagraphs below. Retain first subparagraph for horizontal tanks and some vertical tanks; retain second subparagraph for vertical tanks.

1. Carbon-steel ladder inside tank, anchored to top and bottom, and located as indicated. Include reinforcement of tank at bottom of ladder.
2. Carbon-steel ladder outside tank, anchored to top and side wall. Comply with requirements in Section 055000 "Metal Fabrications" for exterior steel ladder.
 - a. Cage: Include welded steel cage around ladders for tanks [20 feet (6 m)]<Insert dimension> high or higher.
- G. Supply Tube: Extension of supply piping fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).
- H. Sounding and Gauge Tubes: Extension of fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).

2.9 FUEL-OIL-LEVEL GAUGE SYSTEM

Retain this article if fuel-oil-level gauge system is not specified in "Leak-Detection and Monitoring System" Article. Delete this article if fuel-oil-level gauge system is included in the leak-detection and monitoring system.

Retain "Manufacturers" Paragraph and list of manufacturers below to require products from manufacturers listed or a comparable product from other manufacturers.

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Caldwell Systems Corporation]
2. [Franklin Fueling Systems]
3. [Gems Sensors & Controls Inc.]
4. [Highland Tank & Manufacturing Company, Inc.]
5. [In-Situ, Inc]
6. [Pneumercator Inc]
7. [Preferred Utilities Manufacturing Corporation]
8. [Rochester Sensors]
9. [Veeder-Root Company (The)]
10. [Venture Measurement Company, LLC]
11. <Insert manufacturer's name>

Retain "Basis-of-Design Product" Paragraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [Caldwell Systems Corporation]
2. [Franklin Fueling Systems]
3. [Gems Sensors & Controls Inc.]
4. [Highland Tank & Manufacturing Company, Inc.]
5. [In-Situ, Inc]
6. [Pneumercator Inc]
7. [Preferred Utilities Manufacturing Corporation]
8. [Rochester Sensors]
9. [Veeder-Root Company (The)]
10. [Venture Measurement Company, LLC]
11. <Insert manufacturer's name>

- C. Source Limitations: Obtain fuel-oil-level gauge system from single manufacturer.

- D. Description: Calibrated fuel-oil-level gauge system complying with **[UL 180 with floats][UL 1238 with probes]** or other sensors and remote annunciator panel.

Alarms specified in "Annunciator Panel" Paragraph below may be used as part of fuel-oil leak-detection system.

- E. Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms; fuel indicator with registration in **gallons (liters)**; and overfill alarm. Include gauge volume range that covers fuel-oil storage capacity.
- F. Controls: Electrical, operating on **[120]<Insert voltage>** V ac.

2.10 FUEL-OIL LEAK-DETECTION AND MONITORING SYSTEMS

Retain one of two paragraphs in this article.

- A. Fuel-Oil Leak Detection and Monitoring, Cable and Sensor System: Comply with UL 1238.

Retain "Manufacturers" Subparagraph and list of manufacturers below to require products from manufacturers listed or a comparable product from other manufacturers.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [Caldwell Systems Corporation]
- b. [Containment Solutions, Inc]
- c. [Franklin Fueling Systems]
- d. [Gems Sensors & Controls Inc.]
- e. [Highland Tank & Manufacturing Company, Inc.]
- f. [In-Situ, Inc]
- g. [PermAlert]
- h. [Pneumercator Inc]
- i. [Veeder-Root Company (The)]
- j. <Insert manufacturer's name>

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Caldwell Systems Corporation]
- b. [Containment Solutions, Inc]
- c. [Franklin Fueling Systems]
- d. [Gems Sensors & Controls Inc.]
- e. [Highland Tank & Manufacturing Company, Inc.]
- f. [In-Situ, Inc]
- g. [PermAlert]
- h. [Pneumercator Inc]
- i. [Veeder-Root Company (The)]
- j. <Insert manufacturer's name>

3. Source Limitations: Obtain cable-and-sensor fuel-oil leak-detection and monitoring system from single manufacturer.

Visual and audible alarms in "Fuel-Oil-Level Gauge System" Article may be used as part of leak-detection system.

4. Calibrated fuel-oil leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil storage tanks and fuel-oil piping.
5. Include fittings and devices required for testing.
6. Controls: Electrical, operating on [120]<Insert voltage> V ac.

Retain subparagraphs below for an optional feature that replaces system described in "Fuel-Oil-Level Gauge System" Article.

7. Calibrated fuel-oil-level gauge complying with [UL 180 with floats][UL 1238 with probes] or other sensors and remote annunciator panel.
8. Remote Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms; fuel indicator with registration in gallons (liters); and overfill alarm. Include gauge volume range that covers fuel-oil storage capacity.
9. Remote Annunciator Panel Controls: Electrical, operating on [120]<Insert voltage> V ac.

- B. Fuel-Oil Leak Detection and Monitoring, Hydrostatic System: Comply with UL 1238.

Retain "Manufacturers" Subparagraph and list of manufacturers below to require products from manufacturers listed or a comparable product from other manufacturers.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Caldwell Systems Corporation]**
 - b. **[Containment Solutions, Inc]**
 - c. **[Franklin Fueling Systems]**
 - d. **[Gems Sensors & Controls Inc.]**
 - e. **[Highland Tank & Manufacturing Company, Inc.]**
 - f. **[In-Situ, Inc]**
 - g. **[PermAlert]**
 - h. **[Pneumercator Inc]**
 - i. **[Veeder-Root Company (The)]**
 - j. **<Insert manufacturer's name>**

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Caldwell Systems Corporation]**
 - b. **[Containment Solutions, Inc]**
 - c. **[Franklin Fueling Systems]**
 - d. **[Gems Sensors & Controls Inc.]**
 - e. **[Highland Tank & Manufacturing Company, Inc.]**
 - f. **[In-Situ, Inc]**
 - g. **[PermAlert]**
 - h. **[Pneumercator Inc]**
 - i. **[Veeder-Root Company (The)]**
 - j. **<Insert manufacturer's name>**
3. Source Limitations: Obtain hydrostatic fuel-oil leak-detection and monitoring system from single manufacturer.

Visual and audible alarms in "Fuel-Oil-Level Gauge System" Article may be used as part of leak-detection system.

4. Calibrated fuel-oil leak-detection and monitoring system with brine antifreeze solution, reservoir sensor, and electronic control panel to monitor leaks in inner and outer tank walls.
5. Include fittings and devices required for testing.
6. Controls: Electrical, operating on **[120]<Insert voltage> V ac.**

Retain subparagraphs below for an optional feature that replaces system described in "Fuel-Oil-Level Gauge System" Article.

7. Calibrated fuel-oil-level gauge complying with **[UL 180 with floats][UL 1238 with probes]** or other sensors and remote annunciator panel.
8. Remote Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms; fuel indicator with registration in **gallons (liters)**; and overfill alarm. Include gauge volume range that covers fuel-oil storage capacity.
9. Remote Annunciator Panel Controls: Electrical, operating on **[120]<Insert voltage> V ac.**



2.11 FUEL OIL

Second option in "Fuel Oil" Paragraph below is grade typically used for fuel-oil-burning equipment.

- A. Fuel Oil: ASTM D396, **[Grade No. 1][Grade No. 2]**.

Last option in "Diesel Fuel Oil" Paragraph below is typically used for automotive or other diesel engines such as emergency generators.

- B. Diesel Fuel Oil: ASTM D975, **[Grade Low Sulfur][Grade Ultra-Low Sulfur][Grade No. 1-D, special purpose][Grade No. 2-D, general purpose]**, high volatility.

2.12 SOURCE QUALITY CONTROL

Coordinate standards for tests in this article with those referenced in Part 2 Aboveground Fuel-Oil Storage Tanks articles. Do not include STI tests if tanks are not STI type.

- A. Pressure test and inspect fuel-oil storage tanks, after fabrication and before shipment, in accordance with ASME and the following:

Retain one or more of 10 subparagraphs below.

1. Vertical, Single-Wall Steel Aboveground Fuel-Oil Storage Tanks: UL 142.
2. Vertical or Horizontal, Single-Wall Steel Aboveground Fuel-Oil Storage Tanks: UL 142.
3. Horizontal, Single-Wall Steel Aboveground Fuel-Oil Storage Tanks: UL 142.
4. Vertical, Double-Wall Steel Aboveground Fuel-Oil Storage Tanks: UL 142, STI F921, and STI R931.
5. Vertical or Horizontal, Double-Wall Steel Aboveground Fuel-Oil Storage Tanks: UL 142, STI F921, and STI R931.
6. Horizontal, Double-Wall Steel Aboveground Fuel-Oil Storage Tanks: UL 142, STI F921, and STI R931.
7. Horizontal, Containment-Dike, Steel Aboveground Fuel-Oil Storage Tanks: UL 142 and STI F911.
8. Horizontal, Concrete-Vaulted, Steel Aboveground Fuel-Oil Storage Tanks: UL 142 and UL 2085.
9. Horizontal, Concrete-Vaulted and Insulated, Steel Aboveground Fuel-Oil Storage Tanks: UL 142 and UL 2085.
10. Horizontal, Insulated, Steel Aboveground Fuel-Oil Storage Tanks: UL 142 and UL 2085.

- B. Affix standards organization's code stamp.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for aboveground fuel-oil storage tanks to verify actual locations.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 INSTALLATION OF ABOVEGROUND FUEL-OIL STORAGE TANKS

Indicate size and location of concrete base on Drawings, including reinforcing steel.

- A. Install tank in accordance with NFPA 30 and 31 by a tank-manufacturer-trained and -certified contractor.
- B. Install tank bases and supports.

Coordinate concrete work in this article with Section 033000 "Cast-in-Place Concrete."

- C. Concrete Bases: Anchor aboveground fuel oil storage tank to concrete base in accordance with equipment manufacturer's written instructions and in accordance with seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than **4 inches (100 mm)** larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **[18-inch (457-mm)]<Insert dimension>** centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Use **[3000-psi (20.7-MPa)]<Insert dimension>**, 28-day, compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete."
- D. Connect piping and vent fittings.
- E. Install ground connections.
- F. Install tank leak-detection and monitoring devices.
- G. Install steel aboveground fuel-oil storage tanks in accordance with STI R912.
- H. Install insulated and concrete-vaulted, steel, aboveground fuel-oil storage tanks in accordance with STI R942.
- I. Fill storage tanks with fuel oil.

3.4 INSTALLATION OF FUEL-OIL-LEVEL GAUGE SYSTEM

- A. Install liquid-level gauge system. Install panel where indicated on Drawings.

3.5 INSTALLATION OF LEAK-DETECTION AND MONITORING SYSTEM

- A. Install leak-detection and monitoring system. Install alarm panel where indicated on Drawings.
 - 1. Double-Wall, Fuel-Oil Storage Tanks: **[Install probes][Install probes or use factory-installed integral probes][Use factory-installed integral probes]** in interstitial space.

System in "Single-Wall, Fuel-Oil Storage Tanks" Subparagraph below requires extensive description here or layout and details on Drawings.

2. Single-Wall, Fuel-Oil Storage Tanks: Install probes as indicated on Drawings.

Float-type probes in tank containment sumps and at piping low points, if required, are most often used. Cable sensors are also available.

3. Double-Containment Fuel-Oil Piping: Install leak-detection sensor **[probes in fuel-oil storage tank containment sumps and at low points in piping][cable probes in interstitial space of double-containment piping]**.

Retain "Install liquid-level gauge" Subparagraph below for liquid-level gauge that is part of leak-detection and monitoring system.

4. Install liquid-level gauge.

3.6 LABELING AND IDENTIFYING

- A. Nameplates, pipe identification, and signs are specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.7 ABOVEGROUND FUEL-OIL STORAGE TANK, FIELD PAINTING

Retain this article only for aboveground fuel-oil tank with steel exterior surface.

Retain only first paragraph below if shop painting aboveground fuel-oil storage tank.

- A. Prepare and touch up damaged exterior surface of aboveground fuel-oil storage tank **[and supports]** as specified in "Aboveground Fuel-Oil Storage Tank, Shop Painting" Article.

Retain remainder of this article if field painting aboveground fuel-oil storage tank.

- B. Prepare exterior steel surface of aboveground fuel-oil storage tank **[and tank supports]**.

Retain first option in "Field Cleaning" Paragraph below for "Commercial Blast Cleaning"; retain second option for "Near-White Blast Cleaning."

- C. Field Cleaning: After fabrication, blast clean in accordance with **[SSPC-SP 6/NACE No. 3][SSPC-SP 10/NACE No. 2]**.
- D. After cleaning, remove dust or residue from cleaned surfaces.
- E. If surfaces develop rust before prime coat is applied, repeat surface preparation.
- F. Prepare surface of aboveground fuel-oil storage tank **[and supports]** and apply painting systems in accordance with specifications in Section 099600 "High-Performance Coatings" for **[severe][moderate][mild]** environment **[high-gloss][semigloss]** finish for ferrous metal.

3.8 FIELD QUALITY CONTROL

Retain "Manufacturer's Field Service" Paragraph below to require a factory-authorized service representative to perform tests and inspections.



- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

Retain "Perform the following tests and inspections" Paragraph below to require Contractor to perform tests and inspections.

- B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:

Tank and pipe test pressures in this article are required by NFPA 31. Verify requirements with authorities having jurisdiction.

Retain "Tanks" Subparagraph below if storage tanks do not bear the ASME code stamp as required in "Source Quality Control" Article.

1. Tanks: Minimum hydrostatic or compressed-air test pressures for fuel-oil storage tanks that have not been factory tested and do not bear the ASME code stamp or a listing mark acceptable to authorities having jurisdiction:
 - a. Single-Wall Tanks: Minimum **3 psig (20.7 kPa)** and maximum **5 psig (34.5 kPa)**.
 - b. Double-Wall Tanks:
 - 1) Inner Tanks: Minimum **3 psig (20.7 kPa)** and maximum **5 psig (34.5 kPa)**.
 - 2) Interstitial Space: Minimum **3 psig (20.7 kPa)** and maximum **5 psig (34.5 kPa)**, or **5.3-in. Hg (18-kPa)** vacuum.
 - c. Where vertical height of fill and vent pipes is such that the static head imposed on the bottom of the tank is greater than **10 psig (69 kPa)**, hydrostatically test the tank and fill and vent pipes to a pressure equal to the static head thus imposed.
 - d. Maintain the test pressure for one hour.
- C. Aboveground fuel-oil storage tanks will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 23 13 23 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 13 23 13	23 13 23 00	Facility Aboveground Fuel-Oil Storage Tanks
23 13 23 16	22 12 23 26	Facility Fuel-Oil Piping
23 13 23 16	23 11 26 00	Facility Liquefied-Petroleum Gas Piping
23 13 23 16	23 13 23 00	Facility Aboveground Fuel-Oil Storage Tanks
23 13 23 19	22 12 23 26	Facility Fuel-Oil Piping
23 13 23 19	23 11 26 00	Facility Liquefied-Petroleum Gas Piping
23 13 23 19	23 13 23 00	Facility Aboveground Fuel-Oil Storage Tanks
23 13 23 26	22 12 23 26	Facility Fuel-Oil Piping
23 13 23 26	23 13 23 00	Facility Aboveground Fuel-Oil Storage Tanks



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 21 00 00 - UNDERGROUND HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Ductile-iron pipe and fittings.
4. Plastic pipe and fittings.
5. PEX tube and fittings.
6. Fiberglass pipe and fittings.
7. Transition fittings.
8. Preengineered conduit piping system.
9. Preengineered cased piping system.
10. Loose-fill insulation.

1.2 DEFINITIONS

- A. Invert: Vertical distance from Project datum reference point to bottom interior pipe surface.
- B. Reinforced, Thermosetting Resin Fitting (RTRF): Fittings fabricated of composite materials, largely consisting of a reinforcement material embedded in, or surrounded by, cured thermosetting resin. Most common form of reinforced, thermosetting resin pipe is one in which fiberglass strands form reinforcement.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Preengineered conduit piping system components.
2. Preengineered cased piping system components.
3. Cased piping.
4. Loose-fill insulation.

B. Shop Drawings: For underground hydronic piping. Signed and sealed by a professional engineer.

1. Include calculations showing requirements for expansion compensation for underground piping.
2. Show expansion compensators, offsets, and loops with appropriate materials to allow piping movement at required locations. Show anchors and guides that restrain piping movement with calculated loads, and show concrete thrust block dimensions.
3. Show pipe sizes, locations, inverts, and pitch. Show piping in trench, piping in conduit, and cased pipe with details showing clearances between piping.
4. Show insulation thickness.

C. Delegated Design Submittal: For underground hydronic piping systems indicated to comply with performance requirements and design criteria, including analysis data and design drawings signed and sealed by the professional engineer responsible for their preparation.

1. Include design calculations and details for selecting thermal expansion and thrust restraints.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from hydronic distribution piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
- B. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than **1 inch equals 50 feet (1:500)** and at vertical scale of not less than **1 inch equals 5 feet (1:50)**.
 1. Show locations and inverts of utility system manholes and piping. Show manholes and piping. Show types, sizes, materials, and inverts of other utilities crossing hydronic piping.
 2. Show depth of cover from top of hydronic system pipes to finished grade.
- C. Qualification Data: For Installer.
- D. Welding certificates.
- E. Material Test Reports: For **[conduit][cased]** piping, by a qualified testing agency.
- F. Source quality-control reports.
- G. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Fiberglass Pipe and Fitting Installers: Provide RTRF and RTRP pipe installation by technicians certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesives and methods.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with ASME Boiler and Pressure Vessel Code: Section IX.
 1. Comply with provisions in ASME B31.9, "Building Services Piping."
 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

1.6 FIELD CONDITIONS

- A. Interruption of Existing Utilities: Do not interrupt utilities serving occupied facilities unless permitted under the following conditions and then only after arranging to provide temporary utility services in accordance with requirements indicated:
 1. Notify **[Architect][Construction Manager][Owner]** no fewer than **[two]<Insert number>** days in advance of proposed interruption of utility.
 2. Do not proceed with interruption of utility without **[Architect's][Construction Manager's][Owner's]** written permission.

1.7 COORDINATION

- A. Coordinate pipe-fitting pressure classes with products specified in related Sections.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:
 - 1. Hot-Water Piping: [100 psig (690 kPa)][150 psig (1035 kPa)]<Insert value> at [200 deg F (93 deg C)]<Insert temperature>.
 - 2. Chilled-Water Piping: [100 psig (690 kPa)][150 psig (1035 kPa)]<Insert value> at [100 deg F (37 deg C)]<Insert temperature>.
 - 3. Condenser-Water Piping: [100 psig (690 kPa)][150 psig (1035 kPa)]<Insert value> at [150 deg F (66 deg C)]<Insert temperature>.
- B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design underground hydronic piping systems, including restraints and anchors.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: [ASTM B88, Type K (ASTM B88M, Type A)]<Insert type>.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B32, lead-free silver solder alloys. Include water-flushable flux in accordance with ASTM B813.
- E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M, black steel with plain ends; welded and seamless, Grade B, black with plain ends; wall thickness as indicated in "Piping Application" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; standard pattern, with threads in accordance with AME B1.20.1; Class 125 and Class 250 as indicated in "Piping Application" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3; Class 150 and Class 300 as indicated in "Piping Application" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Application" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, [Class 125][and][Class 250]; raised ground face, and bolt holes spot faced.

- F. Wrought-Steel Fittings: ASTM A234/A234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- H. Steel Welding Fittings: ASME B16.9 seamless or welded.
 - 1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- I. Grooved-End-Pipe Couplings for Galvanized-Steel Piping: AWWA C606 for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.
- J. Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.
- K. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, **1/8-inch- (3.2-mm-)** maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat face, Class 125, cast-iron and -bronze flanges.
 - b. Narrow-Face Type: For raised face, Class 250, cast-iron and steel flanges.
- L. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

2.4 DUCTILE-IRON PIPE AND FITTINGS

- A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151/A21.51, centrifugally cast with mechanical-joint bell and plain spigot end.
 - 1. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110/A21.10, ductile or gray iron.
 - 2. Compact-Pattern, Mechanical-Joint Fittings: AWWA C153/A21.53, ductile iron.
 - a. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.5 PLASTIC PIPE AND FITTINGS

- A. CPVC Plastic:
 - 1. Pipe: ASTM F441/F441M, Schedules 40 and 80, plain ends. Make joints as indicated in "Piping Application" Article.
 - 2. Pipe Fittings: Socket-type pipe fittings, ASTM F438 for Schedule 40 pipe; ASTM F439 for Schedule 80 pipe.
 - 3. Solvent Cements: ASTM F493.
- B. PVC Plastic:

1. Pipe: ASTM D1785, Schedules 40 and 80, plain ends. Make joints as indicated in "Piping Application" Article.
 2. Pipe Fittings: Socket-type pipe fittings, ASTM D2466 for Schedule 40 pipe; ASTM D2467 for Schedule 80 pipe.
 3. Solvent Cements: ASTM D2564. Include primer in accordance with ASTM F656.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.6 PEX TUBE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
2. **[FloorHeat LLC]**
3. **[Heat Innovations Inc]**
4. **[HeatLink Group Inc.]**
5. **[Infloor Radiant Heating Inc.]**
6. **[IPEX USA LLC]**
7. **[MrPex Systems Inc]**
8. **[Oatey Co.]**
9. **[REHAU]**
10. **[SharkBite, A Division of Reliance Worldwide Corporation]**
11. **[Sioux Chief Manufacturing Company, Inc.]**
12. **[Uponor Inc.]**
13. **[Viega LLC]**
14. **[Warmboard, Inc.]**
15. **[Watts Radiant; A WATTS Brand]**
16. **[Zurn Industries, LLC]**
17. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
2. **[FloorHeat LLC]**
3. **[Heat Innovations Inc]**
4. **[HeatLink Group Inc.]**
5. **[Infloor Radiant Heating Inc.]**
6. **[IPEX USA LLC]**
7. **[MrPex Systems Inc]**
8. **[Oatey Co.]**
9. **[REHAU]**
10. **[SharkBite, A Division of Reliance Worldwide Corporation]**
11. **[Sioux Chief Manufacturing Company, Inc.]**
12. **[Uponor Inc.]**
13. **[Viega LLC]**
14. **[Warmboard, Inc.]**
15. **[Watts Radiant; A WATTS Brand]**
16. **[Zurn Industries, LLC]**
17. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain PEX tube and fittings from single source from single manufacturer.



- D. Pipe Material: PEX plastic in accordance with ASTM F876.
- E. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at **104 deg F (40 deg C)** in accordance with DIN 4726.
- F. Fittings:
 - 1. **[ASTM F1807, metal insert and copper crimp rings][ASTM F1960, cold expansion fittings and reinforcing rings]**.
 - 2. Factory-fabricated elbows and tees with manufacturer-furnished fitting insulation kit. Provide fittings recommended by and compatible with carrier pipe.
- G. Pressure/Temperature Rating: Minimum **100 psig (690 kPa)** and **180 deg F (82 deg C)**.
- H. Insulation: **[PEX foam]<Insert insulation>** filling annular space between PEX tubing and jacket; thickness indicated in "Piping Application" Article.
- I. Jacket: Corrugated HDPE.

2.7 FIBERGLASS PIPE AND FITTINGS

- A. RTRP: ASTM D2996, filament-wound pipe with tapered bell-and-spigot ends for adhesive joints.
- B. RTRF: Compression or spray up/contact molded of same material, pressure class, and joining method as pipe.
- C. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.
- D. Flanges: ASTM D4024. Full-face gaskets suitable for service, minimum **1/8-inch- (3.2-mm-)** thick, 60-70 durometer. ASTM A307, Grade B, hex-head bolts with washers.

2.8 TRANSITION FITTINGS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Charlotte Pipe and Foundry Company]**
 - 2. **[IPEX USA LLC]**
 - 3. **[Uponor Inc.]**
 - 4. **[Viega LLC]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Charlotte Pipe and Foundry Company]**
 - 2. **[IPEX USA LLC]**
 - 3. **[Uponor Inc.]**
 - 4. **[Viega LLC]**
 - 5. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain transition fittings from single source from single manufacturer.
- D. Plastic-to-Metal Transition Fittings: **[CPVC][and][PVC]** one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cemented-joint end.

2.9 PREENGINEERED CONDUIT PIPING SYSTEM

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Insul-Tek Piping Systems, Inc]**
 - 2. **[PermAlert]**
 - 3. **[Rovanco Piping Systems, Inc]**
 - 4. **[Thermacor Process, L.P.]**
 - 5. **[Tricon Piping Systems, Inc.]**
 - 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Insul-Tek Piping Systems, Inc]**
 - 2. **[PermAlert]**
 - 3. **[Rovanco Piping Systems, Inc]**
 - 4. **[Thermacor Process, L.P.]**
 - 5. **[Tricon Piping Systems, Inc.]**
 - 6. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain piping system from single source from single manufacturer.
- D. Description: Factory-fabricated and -assembled, airtight and watertight, drainable, pressure-tested piping with conduit, inner pipe supports, and insulated carrier piping. Fabricate so insulation can be dried in place by forcing dry air through conduit.
- E. Carrier Pipe: Materials as indicated in "Piping Application" Article. See Part 3 articles in this Section for required carrier pipe.
- F. Carrier Pipe Insulation:
 - 1. Polyurethane Foam Pipe Insulation: Unfaced, preformed, rigid cellular polyurethane material intended for use as thermal insulation.
 - a. Comply with ASTM C591, Type I or Type IV, except thermal conductivity (k-value) may not exceed **0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C)** after 180 days of aging.
 - b. Fabricate shapes in accordance with ASTM C450 and ASTM C585.
- G. Minimum Clearance:
 - 1. Between Carrier Pipe Insulation and Conduit: **1 inch (25 mm)**.
 - 2. Between Insulation of Multiple Carrier Pipes: **3/16 inch (4.75 mm)**.
 - 3. Between Bottom of Carrier Pipe Insulation and Conduit: **1 inch (25 mm)**.
 - 4. Between Bottom of Bare, Carrier Pipe and Casing: **1-3/8 inches (35 mm)**.
- H. Conduit: **[Spiral wound, steel]<Insert conduit material>**.

1. Finish: With two coats of fusion-bonded epoxy, minimum **20 mils (0.50 mm)** thick.
2. Cover: With polyurethane foam insulation with an HDPE jacket; thickness indicated in "Piping Application" Article.
3. Piping Supports within Conduit: Corrugated galvanized steel with a maximum spacing of **10 feet (3 m)**.
4. Fittings: Factory-fabricated and -insulated elbows and tees. Elbows may be bent pipe equal to carrier pipe. Tees to be factory fabricated and insulated, and compatible with carrier pipe.
5. Expansion Offsets and Loops: Size casing to contain piping expansion.
6. Accessories include the following:
 - a. Water Shed: Terminal end protector for carrier pipes entering building through floor, **3 inches (75 mm)** deep and **2 inches (50 mm)** larger than casing; terminate casing **20 inches (500 mm)** above the floor level.
 - b. Guides and Anchors: Steel plate welded to carrier pipes and to casing, complete with vent and drainage openings inside casing.
 - c. End Seals: Steel plate welded to carrier pipes and to casing, complete with drain and vent openings on vertical centerline.
 - d. Gland Seals: Packed stuffing box and gland follower mounted on steel plate, welded to end of casing, permitting axial movement of carrier piping, with drain and vent connections on vertical centerline.
 - e. Joint Kit: Half-shell, pourable or split insulation and shrink-wrap sleeve.

I. Manholes: Black steel with lifting eyes.

1. Finish: Spray-applied urethane, minimum **30 mils (0.75 mm)** thick.
2. Access: **30-inch- (750-mm-)** diameter waterproof cover with gasket, ladder, and two **6-inch (150-mm)** vents, one high and one low, extending above grade with rain caps.
3. Conduit Stub-Outs and Seals: Welded steel with drain and vent openings.
4. Sump: **12 inches (300 mm)** in diameter; **12 inches (300 mm)** deep.
5. Flotation Anchor: Oversized bottom keyed into concrete base.

J. Source Quality Control: Factory test conduit to **15 psig (105 kPa)** for a minimum of two minutes with no change in pressure. Factory test carrier pipe to 150 percent of operating pressure of system. Submit test certificates.

2.10 PREENGINEERED CASSED PIPING SYSTEM

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Insul-Tek Piping Systems, Inc]**
2. **[PermAlert]**
3. **[REHAU]**
4. **[Rovanco Piping Systems, Inc]**
5. **[Thermacor Process, L.P.]**
6. **[Thermal Pipe Systems]**
7. **[Tricon Piping Systems, Inc.]**
8. **[Uponor Inc.]**
9. **[Urecon Ltd]**
10. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [Insul-Tek Piping Systems, Inc]
2. [PermAlert]
3. [REHAU]
4. [Rovanco Piping Systems, Inc]
5. [Thermacor Process, L.P.]
6. [Thermal Pipe Systems]
7. [Tricon Piping Systems, Inc.]
8. [Uponor Inc.]
9. [Urecon Ltd]
10. <Insert manufacturer's name>

- C. Source Limitations: Obtain piping system from single source from single manufacturer.
- D. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.
- E. Carrier Pipe: Materials as indicated in "Piping Application" Article. See articles in this Section for required carrier pipe material characteristics.
- F. Carrier Pipe Insulation:
 1. Polyurethane Foam Pipe Insulation: Rigid, cellular, and high-pressure injected between carrier pipe and jacket.
 - a. Comply with ASTM C591; thermal conductivity (k-value) may not exceed **0.165 Btu x in./h x sq. ft. x deg F (0.024 W/m x K)** at **75 deg F (24 deg C)** after 180 days of aging.
- G. Casing: **[HDPE][Filament-wound, fiberglass-reinforced polyester resin][PVC][0.034-inch- (0.85-mm-) thick, spiral-wound, lock-seam galvanized steel][0.032-inch- (0.80-mm-) thick, spiral-wound, lock-seam aluminum][0.025-inch- (0.65-mm-) thick, spiral-wound, lock-seam stainless steel].**
- H. Casing accessories include the following:
 1. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
 2. Expansion Blanket: Elastomeric foam, formed to fit over piping.
 3. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.
- I. Manholes: Black steel with lifting eyes.
 1. Finish: Spray-applied urethane, minimum **30 mils (0.75 mm)** thick.
 2. Access: **30-inch- (750-mm-)** diameter waterproof cover with gasket, ladder, and two **6-inch (150-mm)** vents, one high and one low, extending above grade with rain caps.
 3. Conduit Stub-Outs and Seals: Welded steel with drain and vent openings.
 4. Sump: **12 inches (300 mm)** in diameter; **12 inches (300 mm)** deep.
 5. Floatation Anchor: Oversized bottom keyed into concrete base.
- J. Cover: With polyurethane foam insulation with an HDPE jacket; thickness indicated in "Piping Application" Article.
- K. Source Quality Control: Factory test carrier pipe to 150 percent of operating pressure of system. Furnish test certificates.

2.11 LOOSE-FILL INSULATION

- A. Granular, Loose-Fill Insulation: Inorganic, nontoxic, nonflammable, sodium potassium aluminum silicate with calcium carbonate filler. Include chemical treatment that renders insulation hydrophobic.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Gilsulate International, Inc.]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Gilsulate International, Inc.]
 - b. <Insert manufacturer's name>
3. Source Limitations: Obtain insulation from single source from single manufacturer.
4. Thermal Conductivity (k-Value): **0.60 at 175 deg F (0.087 at 79 deg C) and 0.65 at 300 deg F (0.094 at 149 deg C).**
5. Application Temperature Range: **35 to 800 deg F (2 to 426 deg C).**
6. Dry Density: **40 to 42 lb/cu. ft. (640 to 672 kg/cu. m).**
7. Strength: **12,000 lb/sq. ft. (58 600 kg/sq. m).**

B. Insulation at Pipe Joints and Fittings:

1. Provide pipe system manufacturer's recommended joint and fitting seals, with formed, spray, or loose-fill insulation. Provide pipe system manufacturer's recommended sealants and adhesives required to form watertight boundaries at outer conduit.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. See Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATION

A. Hot-Water Heating Piping:

1. [NPS 2 (DN 50) and smaller]<Insert pipe size range> to be[any of] the following:
 - a. **Type K (Type A)** copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for direct-buried piping installations.
 - b. **Type K or Type L (Type A or Type B)** copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for jacketed or cased piping installations.
 - c. [Schedule 40][Schedule 80] steel pipe; [Class 50][Class 51] ductile-iron pipe; [Class 125, cast-iron][Class 150, malleable-iron][Class 250, cast-iron][Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 - d. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 - e. [Schedule 40][Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 - f. PEX tube and fittings.
 - g. Loose-Fill Insulation: [Granular][Powder].

2. [NPS 2-1/2 (DN 65) and larger]<Insert pipe size range> to be[any of] the following:
 - a. Type K (Type A) copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for direct-buried piping installations.
 - b. Type K or Type L (Type A or Type B) copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for jacketed or cased piping installations.
 - c. [Schedule 40][Schedule 80] steel pipe; [Class 50][Class 51] ductile-iron pipe; [Class 125, cast-iron][Class 150, malleable-iron][Class 250, cast-iron][Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 - d. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 - e. [Schedule 40][Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 - f. RTRP and RTRF with adhesive or flanged joints.
 - g. Loose-Fill Insulation: [Granular][Powder].
 3. Conduit Piping: Carrier pipe as indicated in "Hot-Water Piping" Paragraph above with polyurethane carrier-pipe insulation and with [coated][coated and insulated] conduit.
 - a. Carrier Pipe Insulation Thickness: [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.
 - b. Conduit Insulation Thickness: [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.
 4. Cased Piping: Polyurethane carrier-pipe insulation.
 - a. Piping Insulation Thickness: [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.
- B. Chilled-Water Piping:
1. [NPS 2 (DN 50) and smaller]<Insert pipe size range> to be[any of] the following:
 - a. Type K (Type A) copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for direct-buried piping installations.
 - b. Type K or Type L (Type A or Type B) drawn-temper copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for jacketed or cased piping installations.
 - c. [Schedule 40][Schedule 80] steel pipe; [Class 50][Class 51] ductile-iron pipe; [Class 125, cast-iron][Class 150, malleable-iron][Class 250, cast-iron][Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 - d. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 - e. [Schedule 40][Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 - f. PEX tube and fittings.
 - g. Loose-Fill Insulation: [Granular][Powder].
 2. [NPS 2-1/2 (DN 65) and larger]<Insert pipe size range> to be[any of] the following:
 - a. Type K (Type A), copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for direct-buried piping installations.
 - b. Type K or Type L (Type A or Type B) copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for jacketed or cased piping installations.
 - c. [Schedule 40][Schedule 80] steel pipe; [Class 50][Class 51] ductile-iron pipe; [Class 125, cast-iron][Class 150, malleable-iron][Class 250, cast-iron][Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 - d. [Schedule 40][Schedule 30][Schedule 20] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - e. Mechanical-joint, ductile-iron pipe; [standard-][or][compact-]pattern mechanical-joint fittings; and mechanical joints.

- f. [Schedule 40][Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 - g. RTRP and RTRF with adhesive or flanged joints.
 - h. Loose-Fill Insulation: [Granular][Powder].
3. Conduit Piping: Carrier pipe as indicated in "Chilled-Water Piping" Paragraph above with polyurethane carrier-pipe insulation and with [coated][coated and insulated] conduit.
- a. Carrier Pipe Insulation Thickness: [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.
 - b. Conduit Insulation Thickness: [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.
4. Cased Piping: Polyurethane carrier-pipe insulation.
- a. Piping Insulation Thickness: [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.

C. Condenser-Water Piping:

1. [NPS 2 (DN 50) and smaller]<Insert pipe size range> to be [any of] the following:
- a. Type K (Type A), copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for direct-buried piping installations.
 - b. Type K or Type L (Type A or Type B) drawn-temper copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for jacketed or cased piping installations.
 - c. [Schedule 40][Schedule 80] steel pipe; [Class 50][Class 51] ductile-iron pipe; [Class 125, cast-iron][Class 150, malleable-iron][Class 250, cast-iron][Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 - d. Mechanical-joint, ductile-iron pipe; [standard-][or][compact-]pattern mechanical-joint fittings; and mechanical joints. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 - e. [Schedule 40][Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 - f. Loose-Fill Insulation: [Granular][Powder].
2. [NPS 2-1/2 (DN 65) and larger]<Insert pipe size range> to be [any of] the following:
- a. Type K (Type A), copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for direct-buried piping installations.
 - b. Type K or Type L (Type A or Type B) copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal] joints for jacketed or cased piping installations.
 - c. [Schedule 40][Schedule 80] steel pipe; [Class 50][Class 51] ductile-iron pipe; [Class 125, cast-iron][Class 150, malleable-iron][Class 250, cast-iron][Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 - d. [Schedule 40][Schedule 30][Schedule 20] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - e. Mechanical-joint, ductile-iron pipe; [standard-][or][compact-]pattern mechanical-joint fittings; and mechanical joints.
 - f. [Schedule 40][Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 - g. RTRP and RTRF with adhesive or flanged joints.

3.3 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to

layout are approved on coordination drawings.

- B. Remove standing water in the bottom of trench.
- C. Bed the pipe on a minimum **6-inch (150-mm)** layer of pipe system manufacturer's recommended granular fill material with a minimum **6-inch (150-mm)** clearance between pipes.
- D. Do not backfill piping trench until field quality-control testing has been completed and results approved.
- E. Install piping at uniform grade of 0.2 percent. Install required fittings to accommodate capped drains at low points and elsewhere as required for system drainage. Install capped manual air vents at high points.
 - 1. Maintain continuous bedding under piping. Do not leave gaps in pipe bedding, allowing pipe to sag between contact points with the bedding.
- F. In conduits, install drain valves at low points and manual air vents at high points.
- G. Install components with pressure rating equal to or greater than system operating pressure.
- H. Install piping in straight lines. Do not bend pipe.
- I. Install fittings for changes in direction and branch connections.
- J. See Section 230500 "Common Work Results for HVAC" for sleeves and mechanical sleeve seals through exterior building walls.
- K. Secure anchors with concrete thrust blocks. Concrete is specified in Section 033000 "Cast-in-Place Concrete."
- L. Connect to hydronic piping where it passes through the building wall. Hydronic piping inside the building is specified in Section 232113 "Hydronic Piping."
- M. See Section 230523 "General-Duty Valves for HVAC Piping" for sleeves and mechanical sleeve seals through exterior building walls.
- N. Secure anchors and fittings where piping changes direction, and where elsewhere required by manufacturer's written installation instructions, with concrete thrust blocks. Concrete is specified in Section 033000 "Cast-in-Place Concrete."
- O. See Section 134713 "Cathodic Protection" for cathodic devices and connections to piping and conduit systems.
- P. Apply bitumastic coating to carbon-steel anchors and guides. Pour concrete thrust blocks and anchors. See Section 033000 "Cast-in-Place Concrete" for concrete and reinforcement.
- Q. After field quality-control testing is complete, backfill with **6 inches (150 mm)** of clean, granular material in accordance with piping system manufacturer's written instructions. If mechanical compaction is required, manually backfill to **12 inches (300 mm)** before using mechanical-compaction equipment.

3.4 INSTALLATION OF LOOSE-FILL INSULATION

- A. Compact and stabilize bottom of trench and bedding to ensure continuous pipe support.

- B. Remove standing water in the bottom of trench before installing pipe.
- C. Bed the pipe on a minimum **6-inch (150-mm)** layer of pipe system manufacturer's recommended granular fill material with a minimum **6-inch (150-mm)** clearance between the pipes.
- D. See Section 312000 "Earth Moving" for requirements of trench backfill materials.
- E. Form insulation trench by excavation or by installing drywall side forms to establish required height and width of insulation.
- F. Support piping with proper pitch, separation, and clearance to backfill or side forms using temporary supporting devices that can be removed after backfilling with insulation.
- G. Place insulation and backfill after field quality-control testing has been completed and results approved.
- H. Insulate piping joints at fittings, expansion loops, and offsets with manufacturer-supplied joint insulation kit. Install insulation of thickness appropriate for calculated expansion amount.
- I. Pour loose-fill insulation to required dimension agitating insulation to eliminate voids around piping.
- J. Maintain pipe system manufacturer's recommended separation between adjacent and crossing pipes and other utilities.
- K. Remove temporary hangers and supports.
- L. Cover loose-fill insulation with polyethylene sheet a minimum of **4 mils (0.10 mm)** thick, and empty loose-fill insulation bags on top.
- M. Manually backfill **6 inches (150 mm)** of clean fill. If mechanical compaction is required, manually backfill to **12 inches (300 mm)** before using mechanical-compaction equipment. Do not compact fill with excavating machinery buckets, wheels, or treads.

3.5 JOINT CONSTRUCTION

- A. See Section 330500 "Common Work Results for Utilities" for basic piping joint construction.
- B. Join pipe and fittings in accordance with the following requirements and Section 232113 "Hydronic Piping":
 - 1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
- D. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," Ch. 35, "Pipe and Tubing," using copper-phosphorus brazing filler metal complying with AWS A5.8M/A5.8.
- E. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1 or ISO 7-1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified processes and welding operators, in accordance with "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:
1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
 2. CPVC Piping: Join in accordance with ASTM D2846/D2846M Appendix X2.
 3. PVC Pressure Piping: Join ASTM D1785 schedule number PVC pipe and PVC socket fittings in accordance with ASTM D2672. Join other-than-schedule number PVC pipe and socket fittings in accordance with ASTM D2855.
- I. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join in accordance with pipe manufacturer's written instructions.
- J. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.
- K. Conduit and Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation and exterior jacket sleeve, and apply shrink-wrap seals.

3.6 IDENTIFICATION

- A. Install continuous plastic underground warning tapes during backfilling of trenches for underground hydronic piping. Locate tapes **6 to 8 inches (150 to 200 mm)** below finished grade, directly over piping. See Section 312000 "Earth Moving" for warning-tape materials and devices and their installation.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections **[with the assistance of a factory-authorized service representative]**.
- D. Tests and Inspections:
1. Prepare hydronic piping for testing in accordance with ASME B31.9 and as follows:
 - a. Leave joints, including welds, uninsulated and exposed for examination during test.
 - b. Isolate equipment and instrumentation. Do not subject equipment and instrumentation to test pressure.
 - c. Install relief valve set to relieve at pressure no more than one-third higher than test

- pressure.
 - d. Fill system with water. Where there is risk of freezing, perform testing with air or liquid that will not freeze or cause damage to piping system materials.
 - e. For hydrostatic testing, install vents at high points to release trapped air while filling system. Remove test liquid at accessible low points.
- 2. Test hydronic piping as follows:
 - a. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times system design pressure.
 - b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
 - c. Do not pressurize carrier pipe with air.
 - d. Maintain test pressure for **[two][four]<Insert number>** hours with no loss of pressure.
- 3. Test conduit as follows:
 - a. Seal vents and drains and subject conduit to **15-psig (105-kPa)** compressed air for four hours with no loss of pressure. Repair leaks and retest.
- E. Piping will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. When successful testing is complete, flush carrier piping to remove dirt or debris remaining after construction. Drain piping after flushing is complete.
- H. Fill underground piping system with permanent system liquid prior to system testing and balancing.

END OF SECTION 23 21 00 00



SECTION 23 21 13 00 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Stainless steel pipe and fittings.
4. Plastic pipe and fittings.
5. Fiberglass pipe and fittings.
6. Piping joining materials.
7. Transition fittings.
8. Dielectric fittings.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show hydronic piping layouts, sizes and elevations, including connecting equipment, valves, specialty valves, fittings, strainers, air vents, expansion tanks, air/dirt separators/purgers, meters, expansion loops/expansion joints/anchors, and low point drains.
2. Show interface and spatial relationships between piping and equipment.
3. Shop Drawing Scale: [1/4 inch equals 1 foot (1:50)]<Insert value>.

C. Delegated Design Submittals:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors, alignment guides, and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

D. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.
2. Environmental Product Declaration (EPD): For each product.
3. Health Product Declaration (HPD): For each product.
4. Environmental Product Declaration (EPD): For each product.
5. Health Product Declaration (HPD): For each product.
6. Environmental Product Declaration (EPD): For each product.
7. Environmental Product Declaration (EPD): For each product.
8. Environmental Product Declaration (EPD): For each product.
9. Third-Party Certifications: For each product.
10. Third-Party-Certified Life-Cycle Assessment: For each product.



1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Piping layout, or BIM model, drawn to scale, indicating the items described in this Section, and coordinated with all building trades.
- B. Qualification Data: For Installer.
- C. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installers of Pressure-Sealed Joints: Installers are to be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
 - 2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP are to be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.
- B. Steel Support Welding: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.
- C. Pipe Welding: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with ASME B31.9 for materials, products, and installation.
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.5 WARRANTY

- A. PP-R and PP-RCT Manufacturer's Warranty: Manufacturer agrees to repair or replace PP-R and PP-RCT pipe and fittings that fail in materials or workmanship within 10 years from date of Substantial Completion.
 - 1. Warranty is to cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.
 - 2. Warranty is to be in effect only upon submission by Contractor to manufacturer of valid pressure/leak documentation indicating that the system was tested and passed manufacturer's pressure/leak test and any other manufacturer requirements.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation are to be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
 - 1. Hot-Water Heating Piping: [100 psig (689 kPa)]<Insert psig (kPa)> at [200 deg F

- (93 deg C)][180 deg F (82 deg C)]<Insert temperature>.
2. Chilled-Water Piping: [150 psig (1034 kPa)]<Insert psig (kPa)> at [73 deg F (22 deg C)]<Insert temperature>.
3. Dual-Temperature Heating- and Cooling-Water Piping: [100 psig (1034 kPa)]<Insert psig (kPa)> at [180 deg F (82 deg C)]<Insert temperature>.
4. Condenser-Water Piping: [150 psig (1034 kPa)]<Insert psig (kPa)> at [73 deg F (66 deg C)]<Insert temperature>.
5. Glycol Cooling-Water Piping: [150 psig (1034 kPa)]<Insert psig (kPa)> at [150 deg F (66 deg C)]<Insert temperature>.
6. Makeup-Water Piping: [80 psig (552 kPa)][150 psig (1034 kPa)]<Insert value> at [73 deg F (22 deg C)][150 deg F (66 deg C)]<Insert temperature>.
7. Condensate-Drain Piping: [150 deg F (66 deg C)][180 deg F (82 deg C)]<Insert temperature>.
8. Air-Vent Piping: [180 deg F (82 deg C)][200 deg F (93 deg C)]<Insert temperature>.
9. Pressure-Relief-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: [ASTM B88, Type K (ASTM B88M, Type A)][and][ASTM B88, Type L (ASTM B88M, Type B)].
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Cambridge-Lee Industries, LLC]
 - b. [Cerro Flow Products, LLC]
 - c. [Mueller Streamline Co.; a company of Mueller Industries]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Cambridge-Lee Industries, LLC]
 - b. [Cerro Flow Products, LLC]
 - c. [Mueller Streamline Co.; a company of Mueller Industries]
 - d. <Insert manufacturer's name>
- B. Annealed-Temper Copper Tube: [ASTM B88, Type K (ASTM B88M, Type A)][and][ASTM B88, Type L (ASTM B88M, Type B)].
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Cambridge-Lee Industries, LLC]
 - b. [Cerro Flow Products, LLC]
 - c. [Mueller Streamline Co.; a company of Mueller Industries]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. [Cambridge-Lee Industries, LLC]
 - b. [Cerro Flow Products, LLC]
 - c. [Mueller Streamline Co.; a company of Mueller Industries]
 - d. <Insert manufacturer's name>
- C. DWV Copper Tube: ASTM B306, Type DWV.
- D. Cast-Copper, Solder-Joint Fittings: ASME B16.18 pressure fittings. Do not use solder joints on pipe sizes greater than **NPS 4 (DN 100)**.
- E. Wrought-Copper, Solder-Joint Fittings: ASME B16.22 pressure fittings. Do not use solder joints on pipe sizes greater than **NPS 4 (DN 100)**.
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]
 - b. [Mueller Streamline Co.; a company of Mueller Industries]
 - c. [NIBCO INC.]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]
 - b. [Mueller Streamline Co.; a company of Mueller Industries]
 - c. [NIBCO INC.]
 - d. <Insert manufacturer's name>
- F. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Do not use solder joints on pipe sizes greater than **NPS 4 (DN 100)**.
- G. Cast-Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends. Do not use solder joints on pipe sizes greater than **NPS 4 (DN 100)**.
- H. Wrought-Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than **NPS 4 (DN 100)**.
- I. Copper-Tube, Mechanically Formed Tee Fitting: For forming T-branch on copper water tube.
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [T-DRILL Industries Inc]
 - c. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[T-DRILL Industries Inc]**
 - c. **<Insert manufacturer's name>**
 3. Description: Tee formed in copper tube in accordance with ASTM F2014.
- J. Grooved, Mechanical-Joint, Copper Tube Appurtenances:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[ASC Engineered Solutions]**
 - c. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - d. **[Smith-Cooper International]**
 - e. **[Star Pipe Products]**
 - f. **[Victaulic Company]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[ASC Engineered Solutions]**
 - c. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - d. **[Smith-Cooper International]**
 - e. **[Star Pipe Products]**
 - f. **[Victaulic Company]**
 - g. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain grooved mechanical-joint copper tube appurtenances from single manufacturer.
 4. Grooved-End Copper Fittings: **ASTM B75 (ASTM B75M)** copper tube or ASTM B584 bronze castings.
 5. Grooved-End-Tube Couplings: To fit copper-tube dimensions; rigid pattern unless otherwise indicated; gasketed fitting EPDM gasket rated for minimum **[230 deg F (110 deg C)]<Insert temperature>** for use with ferrous housing, and steel bolts and nuts; **300 psig (2060 kPa)** minimum CWP pressure rating.
- K. Copper-Tube, Pressure-Seal-Joint Fittings - Copper or Bronze:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Copper Press Brand; Merit Brass Company]**
 - c. **[Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]**



- d. [FNW; Ferguson Enterprises, Inc.]
 - e. [Mueller Streamline Co.; a company of Mueller Industries]
 - f. [NIBCO INC.]
 - g. [Victaulic Company]
 - h. [Viega LLC]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Copper Press Brand; Merit Brass Company]
 - c. [Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]
 - d. [FNW; Ferguson Enterprises, Inc.]
 - e. [Mueller Streamline Co.; a company of Mueller Industries]
 - f. [NIBCO INC.]
 - g. [Victaulic Company]
 - h. [Viega LLC]
 - i. <Insert manufacturer's name>
3. Source Limitations: Obtain copper-tube pressure-seal-joint fittings from single manufacturer.
4. Housing: Copper or bronze.
5. O-Rings and Pipe Stops: EPDM.
6. Tools: Manufacturer's special tools.
7. Minimum **200 psig (1370 kPa)** working pressure rating at **250 deg F (121 deg C)**.

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M black steel with plain ends; welded and seamless, Grade B, and schedule number as indicated in Part 3, "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3, "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3, "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3, "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A234/A234M; wall thickness to match adjoining pipe.
- G. Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- H. Grooved Mechanical-Joint Fittings and Couplings:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[ASC Engineered Solutions]**
 - d. **[GroovJoint]**
 - e. **[National Fittings, Inc]**
 - f. **[Nexus Valve, Inc.; Aalberts Hydronic Flow Control]**
 - g. **[Smith-Cooper International]**
 - h. **[Star Pipe Products]**
 - i. **[Victaulic Company]**
 - j. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[ASC Engineered Solutions]**
 - d. **[GroovJoint]**
 - e. **[National Fittings, Inc]**
 - f. **[Nexus Valve, Inc.; Aalberts Hydronic Flow Control]**
 - g. **[Smith-Cooper International]**
 - h. **[Star Pipe Products]**
 - i. **[Victaulic Company]**
 - j. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain grooved mechanical-joint fittings and couplings from single manufacturer.
 4. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47/A47M, Grade 32510 malleable iron; ASTM A53/A53M, Type F, E, or S, Grade B fabricated steel; or ASTM A106/A106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 5. Couplings: Ductile- or malleable-iron housing and **[EPDM][or][nitrile]** gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- I. Plain-End Mechanical-Joint Couplings:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[NormaGroup]**
 - c. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - d. **[Victaulic Company]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. [Anvil; an ASC Engineered Solution]
- b. [NormaGroup]
- c. [Shurjoint; a part of Aalberts Integrated Piping Systems]
- d. [Victaulic Company]
- e. <Insert manufacturer's name>

3. Source Limitations: Obtain plain-end mechanical-joint couplings from single manufacturer.
4. Housing: ASTM A536, Grade 65-45-12 segmented ductile iron or Type 304 stainless steel.
5. Housing coating: [None]<Insert coating type>.
6. Gasket: [EPDM][NBR].
7. Sealing Mechanism: Double-lip sealing system or carbon steel case-hardened jaws.
8. Bolts, hex nuts, washers, or lock bars based on manufacturer's design.
9. Minimum Pressure Rating: Equal to that of the joined pipes.

- J. Steel Pipe Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 STAINLESS STEEL PIPE AND FITTINGS

- A. Stainless Steel Pipe, Plain Ends: ASTM A312/A312M plain ends, seamless; stainless steel of types and schedules as indicated in Part 3 "Piping Applications" Article.

- B. Appurtenances for Grooved-End, Stainless Steel Pipe:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Anvil; an ASC Engineered Solution]
 - b. [ASC Engineered Solutions]
 - c. [National Fittings, Inc]
 - d. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - e. [Shurjoint; a part of Aalberts Integrated Piping Systems]
 - f. [Smith-Cooper International]
 - g. [Star Pipe Products]
 - h. [Victaulic Company]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Anvil; an ASC Engineered Solution]
 - b. [ASC Engineered Solutions]
 - c. [National Fittings, Inc]
 - d. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - e. [Shurjoint; a part of Aalberts Integrated Piping Systems]
 - f. [Smith-Cooper International]
 - g. [Star Pipe Products]
 - h. [Victaulic Company]
 - i. <Insert manufacturer's name>

3. Source Limitations: Obtain appurtenances for grooved-end stainless steel pipe from single manufacturer.
4. Fittings for Grooved-End, Stainless Steel Pipe: Stainless steel casting with dimensions matching stainless steel pipe.
5. Mechanical Couplings for Grooved-End, Stainless Steel Pipe:
 - a. AWWA C606 for stainless steel pipe dimensions.
 - b. Stainless steel housing sections.
 - c. Stainless steel bolts and nuts.
 - d. EPDM gaskets suitable for hot and cold water.
 - e. Minimum Pressure Rating:
 - 1) NPS 8 (DN 200) and Smaller: **[600 psig (4137 kPa)]<Insert value>**.
 - 2) NPS 10 to NPS 12 (DN 250 to DN 300): **[400 psig (2758 kPa)]<Insert value>**.
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600): **[250 psig (1725 kPa)]<Insert value>**.

C. Stainless Steel Piping, Pressure-Seal-Joint Fittings:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[GroovJoint]**
 - c. **[Merit Brass Company]**
 - d. **[Smith-Cooper International]**
 - e. **[Victaulic Company]**
 - f. **[Viega LLC]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[GroovJoint]**
 - c. **[Merit Brass Company]**
 - d. **[Smith-Cooper International]**
 - e. **[Victaulic Company]**
 - f. **[Viega LLC]**
 - g. **<Insert manufacturer's name>**
3. Obtain stainless steel piping pressure-seal-joint fittings from single manufacturer.
4. Material: ASTM A312/A312M, Type 316, stainless steel, Schedule 10.
5. Fittings: Type O-Rings and Pipe Stop: EPDM.
6. Tools: Manufacturer's special tool.
7. Minimum **300 psig (2070 kPa)** working-pressure rating at **230 deg F (110 deg C)**.

2.5 PLASTIC PIPE AND FITTINGS

- A. CPVC Plastic Pipe: ASTM F441/F441M, with wall thickness as indicated in "Piping Applications" Article.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Charlotte Pipe and Foundry Company]
- b. [IPEX USA LLC]
- c. [Spears Manufacturing Company]
- d. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Charlotte Pipe and Foundry Company]
- b. [IPEX USA LLC]
- c. [Spears Manufacturing Company]
- d. <Insert manufacturer's name>

3. Source Limitations: Obtain CPVC plastic pipe from single manufacturer.
4. CPVC Socket Fittings: [ASTM F438 for Schedule 40][and][ASTM F439 for Schedule 80].
5. CPVC Threaded Fittings: ASTM F437, Schedule 80.
6. CPVC Piping System: ASTM D2846/D2846M, SDR, pipe and socket fittings.
7. CPVC Tubing System: ASTM D2846/D2846M, SDR, tube and socket fittings.

- B. PVC Plastic Pipe: ASTM D1785, with wall thickness as indicated in "Piping Applications" Article.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Charlotte Pipe and Foundry Company]
- b. [IPEX USA LLC]
- c. [Spears Manufacturing Company]
- d. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Charlotte Pipe and Foundry Company]
- b. [IPEX USA LLC]
- c. [Spears Manufacturing Company]
- d. <Insert manufacturer's name>

3. Source Limitations: Obtain PVC plastic pipe from single manufacturer.
4. PVC Socket Fittings: [ASTM D2466 for Schedule 40][and][ASTM D2467 for Schedule 80].
5. PVC Schedule 80 Threaded Fittings: ASTM D2464.

- C. Polypropylene (PP-R and PP-RCT) Pipe:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [aquatherm]
 - b. [Asahi/America]
 - c. [IPEX USA LLC]
 - d. [Nupi Americas]
 - e. [Uponor Inc.]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [aquatherm]
 - b. [Asahi/America]
 - c. [IPEX USA LLC]
 - d. [Nupi Americas]
 - e. [Uponor Inc.]
 - f. <Insert manufacturer's name>
 3. Source Limitations: Obtain polypropylene (PP-R and PP-RCT) pipe from single manufacturer.
 4. Description: ASTM F2389; pipe pressure rating to comply with temperature and pressure ratings of code requirements for the applicable service.
 - a. Polypropylene Fittings: ASTM F2389, socket fusion, butt fusion, electrofusion, or fusion outlet fittings to be used for fusion-welded joints between pipe and fittings.
 - b. Mechanical fittings and transition fittings to be used where transitions are made to other piping materials or to valves and appurtenances.
 - c. Polypropylene pipe is to be unthreaded. Threaded transition fittings in accordance with ASTM F2389 to be used where a threaded connection is required.
- D. Smoke and Fire Ratings:
1. Where indicated on Drawings that a plenum-rated piping system is required, the pipe is to be wrapped and/or insulated with fiberglass or mineral wool pipe insulation; field installed.
 - a. The system is to have a flame-spread classification of less than 25 and smoke-developed rating of less than 50.
 - b. Pipe, wrap, or insulation as a system to comply with the requirements of CAN/ULC-S102.2, ASTM E84, or UL 2846.
 - c. For insulation required for thermal and condensation conditions, see Section 230719 "HVAC Piping Insulation."

2.6 FIBERGLASS PIPE AND FITTINGS

- A. RTRP: ASTM D2996, filament-wound pipe with tapered bell and spigot ends for adhesive joints.
- B. RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.
- C. Flanges: ASTM D4024; full-face gaskets suitable for the service, minimum 1/8-inch (3.2-mm) thick, 60-70 durometer. Provide ASTM A307, Grade B, hex head bolts with washers.

2.7 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, **1/8-inch (3.2-mm)** maximum thickness unless otherwise indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- D. Solder Filler Metals: ASTM B32, lead-free alloys.
- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- F. Flux: ASTM B813, water flushable.
- G. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Solvent Cements for CPVC Piping: ASTM F493.
 1. Product Data: Verify CPVC welding solvent cement has a VOC content of 490 g/L or less.
 2. Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 3. Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 4. Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.
- I. Solvent Cements for PVC Piping: ASTM D2564. Include primer in accordance with ASTM F656.
 1. Product Data:
 - a. Verify PVC welding solvent cement has a VOC content of 510 g/L or less.
 - b. Verify adhesive primer has a VOC content of 550 g/L or less.
 2. Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 3. Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 4. Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m,

- and that of acetaldehyde does not exceed 9 mcg/cu. m.
5. Product Data: Verify adhesive primer complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 6. Product Data: Verify adhesive primer complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 7. Product Data: Verify adhesive primer complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.
- J. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.
1. Verify fiberglass adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).
 2. Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 3. Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 4. Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.

2.8 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Plastic-to-Metal Transition Fittings:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Charlotte Pipe and Foundry Company]**
 - b. **[IPEX USA LLC]**
 - c. **[Uponor Inc.]**
 - d. **[Viega LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Charlotte Pipe and Foundry Company]**
 - b. **[IPEX USA LLC]**
 - c. **[Uponor Inc.]**
 - d. **[Viega LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain plastic-to-metal transition fittings from single manufacturer.
 4. Description:
 - a. **[CPVC][or][PVC]** one-piece fitting with manufacturer's Schedule 80 equivalent dimensions.
 - b. One end with threaded brass insert and one solvent-cement-socket[**or threaded**] end.
 5. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

D. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[aquatherm]**
 - b. **[Charlotte Pipe and Foundry Company]**
 - c. **[IPEX USA LLC]**
 - d. **[NIBCO INC.]**
 - e. **[Spears Manufacturing Company]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[aquatherm]**
 - b. **[Charlotte Pipe and Foundry Company]**
 - c. **[IPEX USA LLC]**
 - d. **[NIBCO INC.]**
 - e. **[Spears Manufacturing Company]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain plastic-to-metal transition unions from single manufacturer.
4. Brass or copper end and solvent-cement-joint end of union to match pipe in size and material.
5. Description:
 - a. **[CPVC][or][PVC]** four-part union.
 - b. Brass[**or stainless steel**] threaded end.
 - c. Solvent-cement-joint[**or threaded**] plastic end.
 - d. Rubber O-ring.
 - e. Union nut.

2.9 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Capitol Manufacturing Company]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[HART Industrial Unions, LLC]**
 - e. **[Jomar Valve]**
 - f. **[Matco-Norca]**
 - g. **[WATTS; A Watts Water Technologies Company]**
 - h. **[Wilkins]**
 - i. **[Zurn Industries, LLC]**
 - j. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Capitol Manufacturing Company]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[HART Industrial Unions, LLC]**
 - e. **[Jomar Valve]**
 - f. **[Matco-Norca]**
 - g. **[WATTS; A Watts Water Technologies Company]**
 - h. **[Wilkins]**
 - i. **[Zurn Industries, LLC]**
 - j. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain dielectric unions from single manufacturer.
 4. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: **[125 psig (860 kPa) minimum at 180 deg F (82 deg C)][150 psig (1035 kPa)][250 psig (1725 kPa)]<Insert value>**.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous. Solder joints are not to be used on pipe sizes greater than **NPS 4 (DN 100)**.
- C. Dielectric Flanges:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[GF Piping Systems: Georg Fischer LLC]**
 - b. **[WATTS; A Watts Water Technologies Company]**

- c. [Wilkins]
- d. [Zurn Industries, LLC]
- e. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [GF Piping Systems: Georg Fischer LLC]
- b. [WATTS; A Watts Water Technologies Company]
- c. [Wilkins]
- d. [Zurn Industries, LLC]
- e. <Insert manufacturer's name>

3. Source Limitations: Obtain dielectric flanges from single manufacturer.

4. Description:

- a. Standard: ASSE 1079.
- b. Factory-fabricated, bolted, companion-flange assembly.
- c. Pressure Rating: [125 psig (860 kPa) minimum at 180 deg F (82 deg C)][150 psig (1035 kPa)][175 psig (1200 kPa)][300 psig (2070 kPa)]<Insert value>.
- d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Advance Products & Systems, LLC]
- b. [CALPICO, Inc.]
- c. [GF Piping Systems: Georg Fischer LLC]
- d. [GPT; a division of EnPRO Industries]
- e. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Advance Products & Systems, LLC]
- b. [CALPICO, Inc.]
- c. [GF Piping Systems: Georg Fischer LLC]
- d. [GPT; a division of EnPRO Industries]
- e. <Insert manufacturer's name>

3. Source Limitations: Obtain dielectric-flange insulating kits from single manufacturer.

4. Description:

- a. Nonconducting materials for field assembly of companion flanges.
- b. Pressure Rating: [150 psig (1035 kPa)]<Insert value>.
- c. Gasket: Neoprene or phenolic.
- d. Bolt Sleeves: Phenolic or polyethylene.
- e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Elster Perfection; Honeywell]**
 - d. **[GPT; a division of EnPRO Industries]**
 - e. **[Matco-Norca]**
 - f. **[Precision Plumbing Products]**
 - g. **[Sioux Chief Manufacturing Company, Inc.]**
 - h. **[Victaulic Company]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Elster Perfection; Honeywell]**
 - d. **[GPT; a division of EnPRO Industries]**
 - e. **[Matco-Norca]**
 - f. **[Precision Plumbing Products]**
 - g. **[Sioux Chief Manufacturing Company, Inc.]**
 - h. **[Victaulic Company]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Obtain dielectric nipples from single manufacturer.
4. Description:
 - a. Standard: IAPMO PS 66.
 - b. Electroplated steel nipple, complying with ASTM F1545.
 - c. Pressure Rating: Minimum **[300 psig (2070 kPa) at 225 deg F (107 deg C)]<Insert value and temperature>**.
 - d. End Connections: Male threaded or grooved.
 - e. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-Water Heating Piping, Aboveground, NPS 2 (DN 50) and Smaller, to Be Any of the Following:**
1. **[Type K (Type A)][Type L (Type B)]<Insert type>**, drawn-temper copper tubing, wrought-copper fittings, and **[soldered][brazed][pressure-seal][grooved mechanical][mechanically formed tee]** joints.
 2. **[Schedule 40]<Insert schedule number>**, Grade B, steel pipe; **[Class 125, cast-iron][Class 150, malleable-iron][Class 250, cast-iron][Class 300, malleable-iron]** fittings; and **[threaded][grooved mechanical]** joints.
 3. Schedule 5, **[Type 304]<Insert type>**, stainless steel pipe; **[Type 316]<Insert type>**, stainless

- steel pressure-seal fittings; and pressure-seal joints.
 4. [Schedule 10][Schedule 40]<Insert schedule number>, [Type 304]<Insert type>, stainless steel pipe; [Type 304]<Insert type>, grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 5. [Schedule 40]<Insert schedule number>, CPVC plastic pipe and fittings and solvent-welded joints.
 6. RTRP and RTRF with adhesive joints.
- B. Hot-Water Heating Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the Following:
1. [Type K (Type A)][Type L (Type B)]<Insert type>, drawn-temper copper tubing, wrought-copper fittings, and [soldered][brazed][grooved mechanical] joints.
 2. [Schedule 40]<Insert schedule number>, Grade B, steel pipe; [Class 125, cast-iron][Class 150, malleable-iron][Class 250 cast-iron][Class 300 malleable-iron] fittings; welded joints, cast-iron flanges, flange-fittings, and flanged joints.
 3. [Schedule 40]<Insert schedule number>, Grade B, steel pipe; grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 4. [Schedule 40]<Insert schedule number>, Grade B, steel pipe, plain-end mechanical joint couplings and fittings; and plain-end mechanical joints.
 5. [Schedule 10][Schedule 40]<Insert schedule number>, [Type 304]<Insert type>, stainless steel pipe; [Type 304]<Insert type>, grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 6. [Schedule 40]<Insert schedule number>, CPVC plastic pipe and fittings and solvent-welded joints.
 7. RTRP and RTRF with adhesive or flanged joints.
- C. Chilled-Water Piping, Aboveground, NPS 2 (DN 50) and Smaller, to be Any of the Following:
1. [Type K (Type A)][Type L (Type B)]<Insert type>, drawn-temper copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal][grooved mechanical][mechanically formed tee] joints.
 2. [Schedule 40]<Insert schedule number>, Grade B steel pipe; [Class 125, cast-iron][Class 150, malleable-iron][Class 250, cast-iron][Class 300, malleable-iron] fittings; and [threaded][grooved mechanical] joints.
 3. Schedule 5, [Type 304]<Insert type>, stainless steel pipe; [Type 316]<Insert type>, stainless steel pressure-seal fittings; and pressure-seal joints.
 4. [Schedule 10][Schedule 40]<Insert schedule number>, [Type 304]<Insert type>, stainless steel pipe; [Type 304]<Insert type>, grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 5. [Schedule 40]<Insert schedule number>, CPVC plastic pipe and fittings and solvent-welded joints.
 6. [PP-R][PP-RCP] plastic piping and fittings with heat fusion joints.
 7. RTRP and RTRF with adhesive or flanged joints.
- D. Chilled-Water Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the Following:
1. [Type K (Type A)][Type L (Type B)]<Insert type>, drawn-temper copper tubing, wrought-copper fittings, and [soldered][brazed][grooved mechanical] joints.
 2. [Schedule 40]<Insert schedule number>, Grade B, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 3. [Schedule 40]<Insert schedule number>, Grade B, steel pipe; grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 4. [Schedule 40]<Insert schedule number>, Grade B, steel pipe, plain-end mechanical joint coupling and fittings; and plain-end mechanical joints.
 5. [Schedule 10][Schedule 40]<Insert schedule number>, [Type 304]<Insert type>, stainless

- steel pipe; [Type 304]<Insert type>, grooved mechanical joint coupling and fittings; and grooved, mechanical joints.
6. [Schedule 40]<Insert schedule number>, CPVC plastic pipe and fittings and solvent-welded joints.
 7. RTRP and RTRF with adhesive or flanged joints.
 8. [PP-R][PP-RCP] plastic piping and fittings with heat fusion joints.
- E. Dual-Temperature Heating- and Cooling-Water Piping, Aboveground, NPS 2 (DN 50) and Smaller, to Be Any of the Following:
1. [Type K (Type A)][Type L (Type B)]<Insert type>, drawn-temper copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal][grooved mechanical][mechanically formed tee] joints.
 2. [Schedule 40]<Insert schedule number>, Grade B steel pipe; [Class 125, cast-iron][Class 150, malleable-iron][Class 250, cast-iron][Class 300, malleable-iron] fittings; and [threaded][grooved mechanical] joints.
 3. Schedule 5, [Type 304]<Insert type>, stainless steel pipe; [Type 316]<Insert Type> stainless steel pressure-seal couplings and fittings; and pressure-seal joints.
 4. [Schedule 10][Schedule 40]<Insert schedule number>, [Type 304]<Insert type>, stainless steel pipe; [Type 304]<Insert type>, grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 5. [Schedule 40]<Insert schedule number>, CPVC plastic pipe and fittings and solvent-welded joints.
 6. [PP-R][PP-RCP] plastic piping and fittings with heat fusion joints.
 7. RTRP and RTRF with adhesive or flanged joints.
- F. Dual-Temperature Heating and Cooling-Water Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the Following:
1. [Type K (Type A)][Type L (Type B)]<Insert type>, drawn-temper copper tubing, wrought-copper fittings, and [soldered][brazed][grooved mechanical] joints.
 2. [Schedule 40]<Insert schedule number>, Grade B steel pipe, [Class 125, cast-iron][Class 150, malleable-iron][Class 250 cast-iron][Class 300 malleable-iron] fittings; welded joints, cast-iron flanges and flange-fittings; and flanged joints.
 3. [Schedule 40]<Insert schedule number>, Grade B steel pipe; grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 4. [Schedule 40]<Insert schedule number>, steel pipe, plain-end mechanical joint couplings and fittings; and plain-end mechanical joints.
 5. [Schedule 10][Schedule 40]<Insert schedule number>, [Type 304]<Insert type>, stainless steel pipe; [Type 304]<Insert type>, grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 6. [Schedule 40]<Insert schedule number>, CPVC plastic pipe and fittings and solvent-welded joints.
 7. RTRP and RTRF with adhesive or flanged joints.
- G. Condenser-Water Piping, Aboveground, NPS 2 (DN 50) and Smaller, to Be Any of the Following:
1. [Type K (Type A)][Type L (Type B)]<Insert type>, drawn-temper copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal][grooved mechanical][mechanically formed tee] joints.
 2. [Schedule 40]<Insert schedule number>, Grade B, steel pipe; [Class 125, cast-iron][Class 150, malleable-iron][Class 250 cast-iron][Class 300 malleable-iron], fittings; and [threaded][grooved mechanical] joints.
 3. Schedule 5, [Type 304]<Insert type>, stainless steel pipe; [Type 316]<Insert type>, stainless steel pressure-seal couplings and fittings; and pressure-seal joints.
 4. [Schedule 10][Schedule 40]<Insert schedule number>, [Type 304]<Insert type>, stainless

- steel pipe; [Type 304]<Insert type>, grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 5. [Schedule 40]<Insert schedule number>, CPVC plastic pipe and fittings and solvent-welded joints.
 6. [PP-R][PP-RCP] plastic piping and fittings with heat fusion joints.
 7. RTRP and RTRF with adhesive joints.
- H. Condenser-Water Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the Following:
1. [Type K (Type A)][Type L (Type B)]<Insert type>, drawn-temper copper tubing, wrought-copper fittings, and [soldered][brazed][grooved mechanical] joints.
 2. [Schedule 40]<Insert schedule number>, Grade B, steel pipe, [Class 125, cast-iron][Class 150, malleable-iron][Class 250 cast-iron][Class 300 malleable-iron] fittings; welded joints, cast-iron flanges and flange-fittings; and flanged joints.
 3. [Schedule 40]<Insert schedule number>, Grade B, steel pipe; grooved, mechanical joint coupling and fittings; and grooved mechanical joints.
 4. [Schedule 40]<Insert schedule number>, steel pipe, plain-end mechanical joint coupling and fittings; and plain-end mechanical joints.
 5. [Schedule 10][Schedule 40]<Insert schedule number>, [Type 304]<Insert type>, stainless steel pipe; [Type 304]<Insert type>, grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 6. [Schedule 40]<Insert schedule number>, CPVC plastic pipe and fittings and solvent-welded joints.
 7. RTRP and RTRF with adhesive or flanged joints.
 8. [PP-R][PP-RCP] piping and fittings with heat fusion joints.
- I. Glycol Cooling-Water Piping, Aboveground, NPS 2 (DN 50) and Smaller, to Be Any of the Following:
1. [Type K (Type A)][Type L (Type B)]<Insert type>, drawn-temper copper tubing, wrought-copper fittings, and [soldered][brazed][pressure-seal][grooved mechanical][mechanically formed tee] joints.
 2. [Schedule 40]<Insert schedule number>, steel pipe; [Class 125, cast-iron][Class 150, malleable-iron][Class 250, cast-iron][Class 300, malleable-iron] fittings; and threaded joints.
 3. Schedule 5, [Type 304]<Insert type>, stainless steel pipe; [Type 316]<Insert type>, stainless steel pressure-seal couplings and fittings; and pressure-seal joints.
 4. [Schedule 10][Schedule 40]<Insert schedule number>, [Type 304]<Insert type>, stainless steel pipe; [Type 304]<Insert type>, grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 5. [Schedule 40]<Insert schedule number>, CPVC plastic pipe and fittings and solvent-welded joints.
 6. [PP-R][PP-RCP] plastic piping and fittings with heat fusion joints.
 7. RTRP and RTRF with adhesive or flanged joints.
- J. Glycol Cooling-Water Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the Following:
1. [Type K (Type A)][Type L (Type B)]<Insert type>, drawn-temper copper tubing, wrought-copper fittings, and [soldered][brazed][grooved mechanical] joints.
 2. [Schedule 40]<Insert schedule number>, Grade B, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 3. [Schedule 40]<Insert schedule number>, Grade B, steel pipe; grooved, mechanical joint coupling and fittings; and grooved mechanical joints.
 4. [Schedule 40]<Insert schedule number>, Grade B, steel pipe, plain-end mechanical joint coupling and fittings; and plain-end mechanical joints.
 5. [Schedule 10][Schedule 40]<Insert schedule number>, [Type 304]<Insert type>, stainless steel pipe; [Type 304]<Insert type>, grooved mechanical joint coupling and fittings; and grooved

- mechanical joints.
 - 6. **[Schedule 40]<Insert schedule number>**, CPVC plastic pipe and fittings and solvent-welded joints.
 - 7. RTRP and RTRF with adhesive or flanged joints.
 - 8. **[PP-R][PP-RCP]** plastic piping and fittings with heat fusion joints.
- K. Makeup-Water Piping Installed Aboveground to Be Any of the Following:
- 1. **[Type K (Type A)][Type L (Type B)]<Insert type>**, drawn-temper copper tubing, wrought-copper fittings, and **[soldered][brazed][pressure-seal][mechanical grooved][mechanically formed tee]** joints.
 - 2. **[Schedule 40]<Insert schedule number>**, CPVC plastic pipe and fittings, and solvent-welded joints.
 - 3. Schedule 5, **[Type 304]<Insert type>**, stainless steel pipe; **[Type 316]<Insert type>**, stainless steel pressure-seal couplings and fittings; and pressure-seal joints.
 - 4. **[Schedule 10][Schedule 40]<Insert schedule number>**, **[Type 304]<Insert type>**, stainless steel pipe; **[Type 304]<Insert type>**, grooved mechanical joint coupling and fittings; and grooved mechanical joints.
 - 5. **[PP-R][PP-RCP]** plastic piping and fittings with heat fusion joints.
 - 6. RTRP and RTRF with adhesive joints.
- L. Condensate-Drain Piping Installed Aboveground to Be Any of the Following:
- 1. **[Type K (Type A)][Type L (Type B)][Type DWV]<Insert type>**, drawn-temper copper tubing, wrought-copper fittings, and **[soldered][brazed][pressure-seal][grooved mechanical][mechanically formed tee]** joints.
 - 2. **[Schedule 40]<Insert schedule number>**, PVC plastic pipe and fittings and solvent-welded joints.
 - 3. Schedule 5, **[Type 304]<Insert type>**, stainless steel pipe; **[Type 316]<Insert type>**, stainless steel pressure-seal couplings and fittings; and pressure-seal joints.
 - 4. **[PP-R][PP-RCP]** plastic piping and fittings with heat fusion joints.
- M. Air-Vent Piping:
- 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems, in accordance with piping manufacturer's written instructions.
 - 2. Outlet: **Type K (Type A)**, annealed-temper copper tubing with soldered or flared joints.
- N. Pressure-Relief-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed, with metal-to-plastic transition fittings for plastic piping systems, in accordance with piping manufacturer's written instructions.

3.2 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.



- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, **NPS 3/4 (DN 20)** ball valve, and short **NPS 3/4 (DN 20)** threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using[**mechanically formed**] tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves in accordance with Section 230523 "General-Duty Valves for HVAC Piping."
- Q. Install air vents and pressure-relief valves in accordance with Section 232116 "Hydronic Piping Specialties."
- R. Install unions in piping, [**NPS 2 (DN 50)**]**<Insert pipe size>** and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- S. Install flanges in piping, [**NPS 2-1/2 (DN 65)**]**<Insert pipe size>** and larger, at final connections of equipment and elsewhere as indicated.
- T. Install shutoff valve immediately upstream of each dielectric fitting.
- U. Comply with requirements in Section 230500 "Common Work Results for HVAC" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
- V. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."
- X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common Work Results for HVAC."

- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

3.3 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
- D. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified processes and welding operators in accordance with "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:
 - 1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. CPVC Piping: Join in accordance with ASTM D2846/D2846M Appendix.
 - 3. PVC Pressure Piping: Join ASTM D1785 schedule number, PVC pipe, and PVC socket fittings in accordance with ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings in accordance with ASTM D2855.
 - 4. PVC Nonpressure Piping: Join in accordance with ASTM D2855.
- I. Fiberglass-Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join in accordance with pipe manufacturer's written instructions.
- J. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
- K. Plain-End Mechanical-Coupled Joints: Prepare, assemble, and test joints in accordance with manufacturer's written installation instructions.
- L. Mechanically Formed Tee Fittings: Use manufacturer-recommended tools, procedure, and brazed joints.

- M. Pressure-Seal Joints: Use manufacturer-recommended tools and procedure. Leave insertion marks on pipe after assembly.

3.4 INSTALLATION OF DIELECTRIC FITTINGS

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric [nipples][unions].
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric [flanges][flange kits][nipples].
- D. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- C. Install hangers for [copper tubing][and][steel piping], with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Install hangers for fiberglass piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- F. Support horizontal piping within [12 inches (300 mm)]<Insert dimension> of each fitting and coupling.
- G. Support vertical runs of [copper tubing][and][steel piping] to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- H. Support vertical runs of [CPVC][PVC][PP-R][and][PP-RCP] piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- I. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections are to be the same as or larger than equipment connections.

- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gauges and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230500 "Common Work Results for HVAC."

3.7 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

3.8 SYSTEM STARTUP

- A. Perform the following before operating the system:
 - 1. Open manual valves fully.
 - 2. Inspect pumps for proper rotation.
 - 3. Set makeup pressure-reducing valves for required system pressure.
 - 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 - 5. Set temperature controls so all coils are calling for full flow.
 - 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 - 7. Verify lubrication of motors and bearings.

3.9 FIELD QUALITY CONTROL

- A. Prepare hydronic piping in accordance with ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure is to be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - 5. Install pressure-relief valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
 - 1. Use ambient-temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 - 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 - 3. Isolate expansion tanks and determine that hydronic system is full of water.
 - 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure is not to exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value



-
- in Appendix A in ASME B31.9.
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.

END OF SECTION 23 21 13 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 21 13 00	23 21 00 00	Underground Hydronic Piping



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 21 13 23 - RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. PEX pipe and fittings.
2. PEX/AL/PEX pipe and fittings.
3. EPDM pipe and fittings.
4. Distribution manifolds.
5. Piping specialties.
6. Controls.

1.2 DEFINITIONS

- A.** CWP: Cold working pressure.
- B.** PEX: Crosslinked polyethylene.
- C.** PEX/AL/PEX: Crosslinked polyethylene/aluminum/crosslinked polyethylene.
- D.** PTFE: Polytetrafluoroethylene plastic.

1.3 ACTION SUBMITTALS

A. Product Data:

1. PEX pipe and fittings.
2. PEX/AL/PEX pipe and fittings.
3. EPDM pipe and fittings.
4. Distribution manifolds.
5. Piping specialties.
6. Controls.
7. For each product, provide the following:
 - a. Data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fire-performance characteristics, and water-flow and pressure-drop characteristics.

- B. Shop Drawings:** Show piping size, layout, and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.

1. Shop Drawing Scale: [1/4 inch = 1 foot (1:50)]<Insert scale>.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:** Piping layout, or Building Information Model (BIM), drawn to scale, showing the

items described in this Section and coordinated with all building trades.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For radiant-heating piping valves and equipment to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Alleguard (formerly Amvic Building System)]**
2. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
3. **[FloorHeat LLC]**
4. **[Heat Innovations Inc]**
5. **[HeatLink Group Inc.]**
6. **[Infloor Radiant Heating Inc.]**
7. **[IPEX USA LLC]**
8. **[MrPex Systems Inc]**
9. **[Oatey Co.]**
10. **[REHAU]**
11. **[SharkBite, A Division of Reliance Worldwide Corporation]**
12. **[Sioux Chief Manufacturing Company, Inc.]**
13. **[Uponor Inc.]**
14. **[Viega LLC]**
15. **[Warmboard, Inc.]**
16. **[WATTS; A Watts Water Technologies Company]**
17. **[Zurn Industries, LLC]**
18. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Alleguard (formerly Amvic Building System)]**
2. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
3. **[FloorHeat LLC]**
4. **[Heat Innovations Inc]**
5. **[HeatLink Group Inc.]**
6. **[Infloor Radiant Heating Inc.]**
7. **[IPEX USA LLC]**
8. **[MrPex Systems Inc]**
9. **[Oatey Co.]**
10. **[REHAU]**
11. **[SharkBite, A Division of Reliance Worldwide Corporation]**
12. **[Sioux Chief Manufacturing Company, Inc.]**
13. **[Uponor Inc.]**
14. **[Viega LLC]**
15. **[Warmboard, Inc.]**

16. [WATTS; A Watts Water Technologies Company]
17. [Zurn Industries, LLC]
18. <Insert manufacturer's name>

- C. Pipe Material: PEX plastic in accordance with ASTM F876.
- D. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at **104 deg F (40 deg C)** in accordance with DIN 4726.
- E. Fittings: [ASTM F1807, metal insert and copper crimp rings][ASTM F1960, cold expansion fittings and reinforcing rings].
- F. Pressure/Temperature Rating: Minimum [90 psig (620 kPa) and 180 deg F (82 deg C)]<Insert pressure and temperature>.

2.2 PEX/AL/PEX PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
2. [FloorHeat LLC]
3. [Heat Innovations Inc]
4. [HeatLink Group Inc.]
5. [Infloor Radiant Heating Inc.]
6. [IPEX USA LLC]
7. [MrPex Systems Inc]
8. [REHAU]
9. [SharkBite, A Division of Reliance Worldwide Corporation]
10. [Sioux Chief Manufacturing Company, Inc.]
11. [Uponor Inc.]
12. [Viega LLC]
13. [Warmboard, Inc.]
14. [WATTS; A Watts Water Technologies Company]
15. [Zurn Industries, LLC]
16. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
2. [FloorHeat LLC]
3. [Heat Innovations Inc]
4. [HeatLink Group Inc.]
5. [Infloor Radiant Heating Inc.]
6. [IPEX USA LLC]
7. [MrPex Systems Inc]
8. [REHAU]
9. [SharkBite, A Division of Reliance Worldwide Corporation]
10. [Sioux Chief Manufacturing Company, Inc.]
11. [Uponor Inc.]
12. [Viega LLC]
13. [Warmboard, Inc.]
14. [WATTS; A Watts Water Technologies Company]



15. **[Zurn Industries, LLC]**
16. **<Insert manufacturer's name>**

- C. Pipe Material: PEX plastic bonded to the inside and outside of a welded aluminum tube in accordance with ASTM F1281.
- D. Oxygen Barrier: Limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at **104 deg F (40 deg C)** in accordance with DIN 4726.
- E. Fittings: ASTM F1974, metal insert fittings with split ring and compression nut (compression joint) or metal insert fittings with copper crimp rings (crimp joint).
- F. Flame-Spread and Smoke-Developed Indices: 25 and 50 or less, respectively, tested in accordance with ASTM E84.
- G. Pressure/Temperature Rating: Minimum **[125 psig (860 kPa) and 180 deg F (82 deg C) <Insert pressure and temperature>**.

2.3 EPDM PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 2. **[Infloor Radiant Heating Inc.]**
 3. **[Therma-HEXX]**
 4. **[WATTS; A Watts Water Technologies Company]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 2. **[Infloor Radiant Heating Inc.]**
 3. **[Therma-HEXX]**
 4. **[WATTS; A Watts Water Technologies Company]**
 5. **<Insert manufacturer's name>**
- C. Pipe Material: Crosslinked EPDM inner and outer tubes.
- D. Wall Thickness: Minimum **0.125 inch (3.2 mm)**.
- E. Oxygen Barrier: Ductile aluminum foil layer applied to the inner tube to limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at **104 deg F (40 deg C)** DIN 4726 DIN 4726.
- F. Reinforcing Braid: Braided-aluminum wire between the inner and outer tube.
- G. Fittings: ASTM F1807, copper with stainless steel crimps or clamps.
- H. Pressure/Temperature Rating: Minimum **[125 psig (860 kPa) and 180 deg F (82 deg C)]<Insert pressure and temperature>**.

2.4 DISTRIBUTION MANIFOLDS

- A. Manifold: Minimum **NPS 1 (DN 25)**, **[brass][copper][modular plastic][or][stainless steel]**.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[FloorHeat LLC]**
 - c. **[Infloor Radiant Heating Inc.]**
 - d. **[MrPex Systems Inc]**
 - e. **[REHAU]**
 - f. **[SharkBite, A Division of Reliance Worldwide Corporation]**
 - g. **[Uponor Inc.]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[FloorHeat LLC]**
 - c. **[Infloor Radiant Heating Inc.]**
 - d. **[MrPex Systems Inc]**
 - e. **[REHAU]**
 - f. **[SharkBite, A Division of Reliance Worldwide Corporation]**
 - g. **[Uponor Inc.]**
 - h. **<Insert manufacturer's name>**
- B. Main Shutoff Valves:
1. Factory installed on supply and return connections.
 2. **[Two][Three]-piece body.**
 3. Body: Brass or bronze.
 4. Ball: Chrome-plated bronze.
 5. Seals: PTFE.
 6. CWP Rating: **125 psig (860 kPa)**.
 7. Maximum Operating Temperature: **180 deg F (82 deg C)**.
- C. Manual Air Vents:
1. Body: Bronze.
 2. Internal Parts: Nonferrous.
 3. Operator: Key furnished with valve or screwdriver bit.
 4. Inlet Connection: **NPS 1/2 (DN 15)**.
 5. Discharge Connection: **NPS 1/8 (DN 6)**.
 6. CWP Rating: **125 psig (860 kPa)**.
 7. Maximum Operating Temperature: **180 deg F (82 deg C)**.
- D. Balancing Valves:
1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
 2. Ball or Plug: Brass or stainless steel.
 3. Globe Cartridge and Washer: Brass with EPDM composition washer.



4. Seat: PTFE.
5. Visual Flow Indicator: Flow meter with visible indication in a clear plastic cap at top of valve.
6. Differential Pressure Gauge Connections: Integral seals for portable meter to measure loss across calibrated orifice.
7. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
8. CWP Rating: Minimum **125 psig (860 kPa)**.
9. Maximum Operating Temperature: **180 deg F (82 deg C)**.

E. Zone Control Valves:

1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
2. Ball or Plug: Brass or stainless steel.
3. Globe Cartridge and Washer: Brass with EPDM composition washer.
4. Seat: PTFE.
5. Actuator: Replaceable electric motor.
6. CWP Rating: Minimum **125 psig (860 kPa)**.
7. Maximum Operating Temperature: **180 deg F (82 deg C)**.

F. Thermometers:

1. Mount on supply and return connections.
2. Case: Dry type, metal or plastic, **[2-inch (50-mm)]<Insert dimension>** diameter.
3. Element: Bimetal or other type of temperature element.
4. Movement: Mechanical, connecting element and pointer.
5. Stem: Stainless steel.
6. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
7. Pointer: Black metal.
8. Window: Plastic.
9. Connector: Rigid, back type.
10. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

G. Mounting Brackets: Copper, or plastic- or copper-clad steel, or stainless steel, where in contact with manifold.

2.5 PIPING SPECIALTIES

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
2. **[FloorHeat LLC]**
3. **[Heat Innovations Inc]**
4. **[Infloor Radiant Heating Inc.]**
5. **[MrPex Systems Inc]**
6. **[REHAU]**
7. **[SharkBite, A Division of Reliance Worldwide Corporation]**
8. **[Therma-HEXX]**
9. **[Uponor Inc.]**
10. **[Viega LLC]**
11. **[Warmboard, Inc.]**
12. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 2. **[FloorHeat LLC]**
 3. **[Heat Innovations Inc]**
 4. **[Infloor Radiant Heating Inc.]**
 5. **[MrPex Systems Inc]**
 6. **[REHAU]**
 7. **[SharkBite, A Division of Reliance Worldwide Corporation]**
 8. **[Therma-HEXX]**
 9. **[Uponor Inc.]**
 10. **[Viega LLC]**
 11. **[Warmboard, Inc.]**
 12. **<Insert manufacturer's name>**
- C. Cable Ties:
1. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
 2. Minimum Width: **1/8 inch (3 mm)**.
 3. Tensile Strength: **20 lb (9 kg)**, minimum.
 4. Temperature Range: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)**.
- D. Floor-Mounting Staples:
1. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
 2. Minimum Thickness: **3/32 inch (2.4 mm)**.
 3. Width: Minimum, wider than tubing.
- E. Floor-Mounting Clamps:
1. Two bolts, steel, with corrosion-resistant coating and smooth finish without sharp edges.
 2. Minimum Thickness: **3/32 inch (2.4 mm)**.
 3. Width: Minimum, wider than tubing.
- F. Floor-Mounting Tracks:
1. Aluminum or plastic channel track with smooth finish and no sharp edges.
 2. Minimum Thickness: **1/16 inch (1.6 mm)**.
 3. Slot Width: Snap fit to hold tubing.
 4. Slot Spacing: **[2-inch (50-mm)][3-inch (75-mm)]<Insert dimension>** intervals.
- G. Channeled Subfloor:
1. Plywood, APA-rated subfloor panel, composed of premium, tongue-and-groove, seven-layer, Douglas fir structural subfloor panels.
 2. Particleboard manufactured to comply with the EPA's Formaldehyde Emission Standards for Composite Wood Products Act.
 3. Clad panel with minimum **0.025-inch- (0.635-mm-)** thick aluminum recessed in the grooves sized to maintain contact with radiant piping.
- H. Modular Interlocking Blocks:
1. Polypropylene snap-together blocks with grooves to support piping.
 2. Galvanized sheet metal or aluminum emission plates.
 3. Natural mineralboard cover panel.



- I. Heat-Emission Plates:
 - 1. Formed aluminum suitable for radiant-heating piping.
 - 2. Minimum Thickness: **1/16 inch (1.6 mm)**.
 - 3. Slot Width: Snap fit to maintain pressure fit on tubing.

2.6 CONTROLS

- A. Temperature-control devices and sequence of operations are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - 2. **[Danfoss, Inc.]**
 - 3. **[FloorHeat LLC]**
 - 4. **[Heat Innovations Inc]**
 - 5. **[HeatLink Group Inc.]**
 - 6. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - 7. **[Infloor Radiant Heating Inc.]**
 - 8. **[MrPex Systems Inc]**
 - 9. **[REHAU]**
 - 10. **[Slant/Fin Corp]**
 - 11. **[tekmar; A WATTS Brand]**
 - 12. **[Therma-HEXX]**
 - 13. **[Uponor Inc.]**
 - 14. **[Viega LLC]**
 - 15. **[Warmboard, Inc.]**
 - 16. **[Zurn Industries, LLC]**
 - 17. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - 2. **[Danfoss, Inc.]**
 - 3. **[FloorHeat LLC]**
 - 4. **[Heat Innovations Inc]**
 - 5. **[HeatLink Group Inc.]**
 - 6. **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - 7. **[Infloor Radiant Heating Inc.]**
 - 8. **[MrPex Systems Inc]**
 - 9. **[REHAU]**
 - 10. **[Slant/Fin Corp]**
 - 11. **[tekmar; A WATTS Brand]**
 - 12. **[Therma-HEXX]**
 - 13. **[Uponor Inc.]**
 - 14. **[Viega LLC]**
 - 15. **[Warmboard, Inc.]**
 - 16. **[Zurn Industries, LLC]**
 - 17. **<Insert manufacturer's name>**

D. Wall-Mounted Thermostat:

1. Minimum temperature range from **[50 to 90 deg F (10 to 32 deg C)]**<Insert temperature range>.
2. Manually operated with on-off switch.
3. Day and night setback and clock program with minimum four periods per day.
4. Operate pumps or open zone control valves if room temperature falls below the thermostat setting, and stop pumps or close zone control valves when room temperature rises above the thermostat setting.

E. Heated-Panel Thermostat:

1. Remote bulb unit with adjustable temperature range from **[50 to 90 deg F (10 to 32 deg C)]**<Insert temperature range>.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump or zone control valve.
3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant-panel temperature.
4. Stop pump or close zone control valves if heated-panel thermostat setting is exceeded.
5. Corrosion-resistant, waterproof control enclosure.

F. Heated-Panel Thermostat with Outdoor Temperature Reset:

1. Remote bulb unit with adjustable temperature range from **[50 to 90 deg F (10 to 32 deg C)]**<Insert temperature range>.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump.
 - a. Pump stops when outdoor-air temperature rises above **[60 deg F (16 deg C)]**.
3. Remote bulbs on capillary tube, resistance temperature device, or thermistor for directly sensing each of the following:
 - a. Supply-water temperature.
 - b. Outdoor-air temperature.
4. Modulate zone control valves to reset supply-water temperature inversely with outdoor-air temperature as follows:
 - a. Supply-water temperature set point **[110 deg F (43 deg C)]** when outdoor-air temperature is **[0 deg F (minus 18 deg C)]**.
 - b. Supply-water temperature set point **[60 deg F (16 deg C)]** when outdoor-air temperature is **[60 deg F (16 deg C)]**.
 - c. Supply-water temperature set point is reset inversely as outdoor-air temperature varies between high and low temperatures.
5. Corrosion-resistant, waterproof control enclosure.

G. Precipitation and Temperature Sensor:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**

- b. [tekmar; A WATTS Brand]
 - c. [Uponor Inc.]
 - d. [Viega LLC]
 - e. [Zurn Industries, LLC]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [tekmar; A WATTS Brand]
 - c. [Uponor Inc.]
 - d. [Viega LLC]
 - e. [Zurn Industries, LLC]
 - f. <Insert manufacturer's name>
3. [Microprocessor-based][Automatic] control with manual on, automatic, and standby/reset switch.
- a. Surface Temperature Span: [40 to 60 deg F (4 to 16 deg C)]<Insert temperature range>.
 - b. Adjustable Delay Off Span: [30 to 90]<Insert numbers> minutes.
4. Precipitation and temperature sensors are to sense the surface conditions of pavement and is to be programmed to operate pump and zone control valves as follows:
- a. Start Pump or Open Zone Control Valves: Following [two]<Insert number>-minute delay if ambient temperature is below [40 deg F (4 deg C)]<Insert temperature> and precipitation is detected.
 - b. Modulate zone control valve to maintain slab surface at [45 deg F (7 deg C)]<Insert temperature>.
 - c. Stop Pump or Close Zone Control Valves
 - 1) On detection of a dry surface plus time delay.
 - 2) If ambient temperature rises above [44 deg F (7 deg C)]<Insert temperature>.
 - d. Sensor-controller overrides zone control valve to prevent hot-water inlet temperature from exceeding [140 deg F (60 deg C)] <Insert temperature> and slab surface temperature from exceeding 68 deg F (20 deg C).
5. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
6. Minimum 30 A contactor to start pump and open valves.
7. Precipitation sensor is to be flush-mounted in pavement.
8. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control-system workstation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and substrates to receive radiant-heating piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Ensure that surfaces and pipes in contact with radiant-heating piping are free of burrs and sharp protrusions.
 2. Ensure that surfaces and substrates are level and plumb.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Install the following types of radiant-heating piping for the applications described:
1. Piping in Exterior Pavement: [EPDM][PEX][PEX/AL/PEX].
 2. Piping in Interior Reinforced-Concrete Floors: [EPDM][PEX][PEX/AL/PEX].
 3. Piping in Level-Fill Unreinforced Concrete Floors: [EPDM][PEX][PEX/AL/PEX].
 4. Piping in Ceilings and Walls: [EPDM][PEX][PEX/AL/PEX].
 5. Piping in Subfloors: [EPDM][PEX][PEX/AL/PEX].
 6. Piping below Wood Floors: [EPDM][PEX][PEX/AL/PEX].

3.3 INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings or coordination drawings.
- B. Install radiant-heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.
- C. Connect radiant piping to manifold in a reverse-return arrangement.
- D. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.
- E. Install manifolds in accessible locations or install access panels to provide maintenance access as required in Section 083113 "Access Doors and Frames."
- F. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties" for pipes and connections to hydronic systems and for glycol-solution fill requirements.
- G. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials in accordance with Section 078413 "Penetration Firestopping."
- H. Piping in Exterior Pavement:
1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 2. Space cable ties a maximum of [18 inches (457 mm)]<Insert dimension> o.c. and at center of turns or bends.
 3. Maintain [3-inch (75-mm)]<Insert dimension> minimum cover.
 4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of [10 inches (250 mm)]<Insert dimension> on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 5. Maintain minimum 40 psig (275 kPa) pressure in piping during concrete placement and continue for 24 hours after placement.

- I. Piping in Interior Reinforced-Concrete Floors:
 - 1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 - 2. Space cable ties a maximum of [18 inches (457 mm)]<Insert dimension> o.c. and at center of turns or bends.
 - 3. Maintain [2-inch (50-mm)]<Insert dimension> minimum cover.
 - 4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of [10 inches (250 mm)]<Insert dimension> on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - 5. Maintain minimum 40 psig (275 kPa) pressure in piping during concrete placement and continue for 24 hours after placement.
- J. Piping in Level Fill Concrete Floors (Not Reinforced):
 - 1. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
 - 2. Space tracks, clamps, or staples a maximum of [18 inches (457 mm)]<Insert dimension> o.c. and at center of turns or bends.
 - 3. Maintain [3/4-inch (19-mm)]<Insert dimension> minimum cover.
 - 4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of [10 inches (250 mm)]<Insert dimension> on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - 5. Maintain minimum 40 psig (275 kPa) pressure in piping during the concrete pour and continue for 24 hours during curing.
- K. Piping in Ceiling and Walls:
 - 1. Secure piping by attaching pipes to ceiling or wall substrate using clamps or staples.
 - 2. Space clamps or staples a maximum of [18 inches (457 mm)]<Insert dimension> o.c. and at center of turns or bends.
 - 3. Maintain [1-1/2-inch (38-mm)]<Insert dimension> minimum plaster cover.
 - 4. Maintain minimum 40 psig (275 kPa) pressure in piping during the plaster application and continue for 24 hours during curing.
- L. Piping in Subfloor:
 - 1. Secure piping by laying in subfloor channels or modular interlocking blocks.
 - 2. Use straight-channel panels or blocks in the center and curved-channel panels or blocks at the ends.
 - 3. Finish floor with mineralboard panel cover or finished floor surface.
- M. Piping below Wood Floor:
 - 1. Secure piping by attaching pipes to subfloor using heat-emission plates, clamps, or staples.
 - 2. Space heat-emission plates, clamps, or staples a maximum of [4 inches (100 mm)]<Insert dimension> o.c. and at center of turns or bends.
 - 3. Install heat-emission plates on underside of wood subfloor with maximum space between plates, as noted above, to maintain pipe contact with floor.
- N. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.
- O. After system balancing has been completed, mark balancing valves to permanently indicate final position.

- P. Perform the following adjustments before operating the system:
1. Open valves to fully open position.
 2. Check operation of automatic valves.
 3. Set temperature controls so all zones call for full flow.
 4. Purge air from piping.
- Q. After concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant-heating system as follows:
1. Start system heating at a maximum of **10 deg F (6 deg C)** above the ambient radiant-panel temperature and increase **10 deg F (6 deg C)** each following day until design temperature is achieved.
 2. For freeze protection, operate at a minimum of **60 deg F (16 deg C)** supply-water temperature.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
1. Prepare radiant-heating piping for testing as follows:
 - a. Open all isolation valves and close bypass valves.
 - b. Open and verify operation of zone control valves.
 - c. Flush with clean water and clean strainers.
 2. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - a. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than **[100 psig (690 kPa)]<Insert value>**. Repair leaks and retest until no leaks exist.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Radiant-heating piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.
- D. Protect hydronic piping system from damage during construction.

END OF SECTION 23 21 13 23



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 21 13 23	21 05 00 00	Common Work Results for Fire Suppression
23 21 13 23	22 05 00 00	Common Work Results for Plumbing
23 21 13 23	22 11 16 00	Domestic Water Piping
23 21 13 23	22 13 16 00	Sanitary Waste And Vent Piping
23 21 13 23	22 11 16 00a	Storm Drainage Piping
23 21 13 23	22 15 13 00	General-Service Compressed-Air Piping
23 21 13 23	22 11 16 00b	Compressed-Air Piping For Laboratory And Healthcare Facilities
23 21 13 23	22 11 16 00c	Vacuum Piping For Laboratory And Healthcare Facilities
23 21 13 23	22 63 13 00	Gas Piping For Laboratory And Healthcare Facilities
23 21 13 23	23 05 00 00	Common Work Results for HVAC
23 21 13 23	22 12 23 26	Facility Fuel-Oil Piping
23 21 13 23	23 11 23 00	Facility Natural-Gas Piping
23 21 13 23	23 11 26 00	Facility Liquefied-Petroleum Gas Piping
23 21 13 23	23 21 13 00	Hydronic Piping
23 21 13 23	23 21 00 00	Underground Hydronic Piping
23 21 13 23	22 11 16 00d	Steam And Condensate Piping
23 21 13 23	23 23 00 00	Refrigerant Piping
23 21 13 23	33 11 13 00a	Potable Water Supply Wells



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 21 16 00 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air vents.
3. Expansion tanks and fittings.
4. Air/dirt separators and purgers.
5. Strainers.
6. Flexible connectors.

B. Related Requirements:

1. Section 230500 "Common Work Results for HVAC" for expansion fittings and loops.
2. Section 230523 "General-Duty Valves for HVAC Piping" for specification and installation requirements for general-duty valves common to most piping systems.
3. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:** For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter:** For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.5 QUALITY ASSURANCE

- A. Pipe Welding:** Qualify procedures and operators in accordance with ASME BPVC, Section IX.
- B. Pressure-relief and safety-relief valves and pressure vessels** bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME BPVC, Section VIII,

Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Armstrong Fluid Technology]**
 - d. **[Bell & Gossett; a Xylem brand]**
 - e. **[Flamco; a division of AALBERTS Ind.]**
 - f. **[Gerand Engineering Co]**
 - g. **[Griswold Controls, LLC]**
 - h. **[Hays Fluid Controls]**
 - i. **[HCI; Hydronics Components Inc.]**
 - j. **[IMI Flow Design, Inc.]**
 - k. **[Jenkins Valves; a Crane Co. brand]**
 - l. **[Jomar Valve]**
 - m. **[Nexus Valve, Inc.; Aalberts Hydronic Flow Control]**
 - n. **[NIBCO INC.]**
 - o. **[NuTech Hydronic Specialty Products]**
 - p. **[Oventrop Corporation]**
 - q. **[Red-White Valve Corp.]**
 - r. **[Taco Comfort Solutions]**
 - s. **[Tour & Andersson; available through Victaulic Company]**
 - t. **[Tunstall Corporation]**
 - u. **[Victaulic Company]**
 - v. **[WATTS; A Watts Water Technologies Company]**
 - w. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Armstrong Fluid Technology]**
 - d. **[Bell & Gossett; a Xylem brand]**
 - e. **[Flamco; a division of AALBERTS Ind.]**
 - f. **[Gerand Engineering Co]**
 - g. **[Griswold Controls, LLC]**
 - h. **[Hays Fluid Controls]**
 - i. **[HCI; Hydronics Components Inc.]**
 - j. **[IMI Flow Design, Inc.]**
 - k. **[Jenkins Valves; a Crane Co. brand]**
 - l. **[Jomar Valve]**

- m. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - n. [NIBCO INC.]
 - o. [NuTech Hydronic Specialty Products]
 - p. [Oventrop Corporation]
 - q. [Red-White Valve Corp.]
 - r. [Taco Comfort Solutions]
 - s. [Tour & Andersson; available through Victaulic Company]
 - t. [Tunstall Corporation]
 - u. [Victaulic Company]
 - v. [WATTS; A Watts Water Technologies Company]
 - w. <Insert manufacturer's name>
- 3. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 - 4. Ball: Brass or stainless steel.
 - 5. Plug: Resin.
 - 6. Seat: PTFE.
 - 7. End Connections: Threaded or socket.
 - 8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
 - 9. Handle Style: Lever, with memory stop to retain set position.
 - 10. CWP Rating: Minimum **125 psig (860 kPa)**.
 - 11. Maximum Operating Temperature: **250 deg F (121 deg C)**.
- B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Anvil; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Armstrong Fluid Technology]
 - d. [ASC Engineered Solutions]
 - e. [Bell & Gossett; a Xylem brand]
 - f. [Flamco; a division of AALBERTS Ind.]
 - g. [Gerand Engineering Co]
 - h. [Griswold Controls, LLC]
 - i. [Hammond Valve]
 - j. [Hays Fluid Controls]
 - k. [HCI; Hydronics Components Inc.]
 - l. [IMI Flow Design, Inc.]
 - m. [IMI Hydronic Engineering Inc]
 - n. [Jenkins Valves; a Crane Co. brand]
 - o. [Jomar Valve]
 - p. [KITZ Corporation]
 - q. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - r. [NIBCO INC.]
 - s. [NuTech Hydronic Specialty Products]
 - t. [Oventrop Corporation]
 - u. [Red-White Valve Corp.]
 - v. [Tour & Andersson; available through Victaulic Company]
 - w. [Tunstall Corporation]
 - x. [Victaulic Company]
 - y. [WATTS; A Watts Water Technologies Company]
 - z. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Anvil; an ASC Engineered Solution]
- b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
- c. [Armstrong Fluid Technology]
- d. [ASC Engineered Solutions]
- e. [Bell & Gossett; a Xylem brand]
- f. [Flamco; a division of AALBERTS Ind.]
- g. [Gerand Engineering Co]
- h. [Griswold Controls, LLC]
- i. [Hammond Valve]
- j. [Hays Fluid Controls]
- k. [HCI; Hydronics Components Inc.]
- l. [IMI Flow Design, Inc.]
- m. [IMI Hydronic Engineering Inc]
- n. [Jenkins Valves; a Crane Co. brand]
- o. [Jomar Valve]
- p. [KITZ Corporation]
- q. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
- r. [NIBCO INC.]
- s. [NuTech Hydronic Specialty Products]
- t. [Oventrop Corporation]
- u. [Red-White Valve Corp.]
- v. [Tour & Andersson; available through Victaulic Company]
- w. [Tunstall Corporation]
- x. [Victaulic Company]
- y. [WATTS; A Watts Water Technologies Company]
- z. **<Insert manufacturer's name>**

- 3. Body: Cast-iron or steel body, ball, butterfly, plug, or globe pattern with calibrated orifice or venturi.
- 4. Ball: Brass or stainless steel.
- 5. Stem Seals: EPDM O-rings.
- 6. Disc: Glass- and carbon-filled PTFE.
- 7. Seat: PTFE.
- 8. End Connections: Flanged or grooved.
- 9. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
- 10. Handle Style: Lever, with memory stop to retain set position.
- 11. CWP Rating: Minimum **125 psig (860 kPa)**.
- 12. Maximum Operating Temperature: **250 deg F (121 deg C)**.

- C. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Bell & Gossett; a Xylem brand]
 - c. [Caleffi North America]
 - d. [Jenkins Valves; a Crane Co. brand]
 - e. [Keckley Company]

- f. [NIBCO INC.]
 - g. [Oventrop Corporation]
 - h. [Spence Engineering Company, Inc]
 - i. [Taco Comfort Solutions]
 - j. [Victaulic Company]
 - k. [WATTS; A Watts Water Technologies Company]
 - l. [Zurn Industries, LLC]
 - m. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Bell & Gossett; a Xylem brand]
 - c. [Caleffi North America]
 - d. [Jenkins Valves; a Crane Co. brand]
 - e. [Keckley Company]
 - f. [NIBCO INC.]
 - g. [Oventrop Corporation]
 - h. [Spence Engineering Company, Inc]
 - i. [Taco Comfort Solutions]
 - j. [Victaulic Company]
 - k. [WATTS; A Watts Water Technologies Company]
 - l. [Zurn Industries, LLC]
 - m. <Insert manufacturer's name>
 - 3. Body: Bronze or brass.
 - 4. Disc: [Brass][EPDM].
 - 5. Seat: [Brass][Steel].
 - 6. Stem Seals: EPDM O-rings.
 - 7. Diaphragm: EPDM.
 - 8. Low inlet-pressure check valve.
 - 9. Inlet Strainer: <Insert materials>, removable without system shutdown.
 - 10. Valve Seat and Stem: Noncorrosive.
 - 11. Valve Size and Capacity: As indicated on Drawings.
 - 12. Operating Pressure: Factory set and field adjustable.
- D. Diaphragm-Operated Pressure-Relief Valves: ASME labeled.
- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Bell & Gossett; a Xylem brand]
 - c. [Flamco; a division of AALBERTS Ind.]
 - d. [Keckley Company]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Bell & Gossett; a Xylem brand]
 - c. [Flamco; a division of AALBERTS Ind.]
 - d. [Keckley Company]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
3. Body: Bronze or brass.
 4. Disc: [Brass][Steel].
 5. Seat: [Brass][Steel].
 6. Stem Seals: EPDM O-rings.
 7. Diaphragm: EPDM.
 8. Valve Seat and Stem: Noncorrosive.
 9. Valve Size, Capacity, and Operating Pressure: Comply with ASME BPVC, Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Anvil; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Bell & Gossett; a Xylem brand]
 - d. [Caleffi North America]
 - e. [Flamco; a division of AALBERTS Ind.]
 - f. [Flowcon Americas LLC]
 - g. [Griswold Controls, LLC]
 - h. [Hays Fluid Controls]
 - i. [HCI; Hydronics Components Inc.]
 - j. [IMI Flow Design, Inc.]
 - k. [IMI Hydronic Engineering Inc]
 - l. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - m. [NIBCO INC.]
 - n. [NuTech Hydronic Specialty Products]
 - o. [Oventrop Corporation]
 - p. [Red-White Valve Corp.]
 - q. [Spence Engineering Company, Inc]
 - r. [Tunstall Corporation]
 - s. [Victaulic Company]
 - t. [WATTS; A Watts Water Technologies Company]
 - u. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Anvil; an ASC Engineered Solution]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Bell & Gossett; a Xylem brand]
 - d. [Caleffi North America]

- e. [Flamco; a division of AALBERTS Ind.]
 - f. [Flowcon Americas LLC]
 - g. [Griswold Controls, LLC]
 - h. [Hays Fluid Controls]
 - i. [HCI; Hydronics Components Inc.]
 - j. [IMI Flow Design, Inc.]
 - k. [IMI Hydronic Engineering Inc]
 - l. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - m. [NIBCO INC.]
 - n. [NuTech Hydronic Specialty Products]
 - o. [Oventrop Corporation]
 - p. [Red-White Valve Corp.]
 - q. [Spence Engineering Company, Inc]
 - r. [Tunstall Corporation]
 - s. [Victaulic Company]
 - t. [WATTS; A Watts Water Technologies Company]
 - u. <Insert manufacturer's name>
- 3. Body: Brass or ferrous metal.
 - 4. Combination Assemblies: Include bronze or brass-alloy ball valve.
 - 5. Identification Tag: Marked with zone identification, valve number, and flow rate.
 - 6. Size and Capacity: For each application, provide a valve with rated capacity equal to or greater than capacity of device being served.
 - 7. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
 - 8. Minimum CWP Rating: [175 psig (1207 kPa)][300 psig (2070 kPa)].
 - 9. Maximum Operating Temperature: [200 deg F (93 deg C)][250 deg F (121 deg C)].

2.2 AIR VENTS

A. Manual Air Vents:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Bell & Gossett; a Xylem brand]
 - c. [Caleffi North America]
 - d. [Flamco; a division of AALBERTS Ind.]
 - e. [HCI; Hydronics Components Inc.]
 - f. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - g. [NuTech Hydronic Specialty Products]
 - h. [Taco Comfort Solutions]
 - i. [WATTS; A Watts Water Technologies Company]
 - j. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Bell & Gossett; a Xylem brand]
 - c. [Caleffi North America]

- d. [Flamco; a division of AALBERTS Ind.]
- e. [HCl; Hydronics Components Inc.]
- f. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
- g. [NuTech Hydronic Specialty Products]
- h. [Taco Comfort Solutions]
- i. [WATTS; A Watts Water Technologies Company]
- j. <Insert manufacturer's name>

- 3. Body: Bronze.
- 4. Internal Parts: Nonferrous.
- 5. Operator: Screwdriver or thumbscrew.
- 6. Inlet Connection: **NPS 1/2 (DN 15)**.
- 7. Discharge Connection: **NPS 1/8 (DN 6)**.
- 8. CWP Rating: **150 psig (1035 kPa)**.
- 9. Maximum Operating Temperature: **225 deg F (107 deg C)**.

B. Automatic Air Vents:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Bell & Gossett; a Xylem brand]
 - c. [Caleffi North America]
 - d. [Flamco; a division of AALBERTS Ind.]
 - e. [Flo Fab Inc]
 - f. [Metraflex Company (The)]
 - g. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - h. [NuTech Hydronic Specialty Products]
 - i. [Oventrop Corporation]
 - j. [Spirotherm, Inc.]
 - k. [Taco Comfort Solutions]
 - l. [WATTS; A Watts Water Technologies Company]
 - m. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Bell & Gossett; a Xylem brand]
 - c. [Caleffi North America]
 - d. [Flamco; a division of AALBERTS Ind.]
 - e. [Flo Fab Inc]
 - f. [Metraflex Company (The)]
 - g. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - h. [NuTech Hydronic Specialty Products]
 - i. [Oventrop Corporation]
 - j. [Spirotherm, Inc.]
 - k. [Taco Comfort Solutions]
 - l. [WATTS; A Watts Water Technologies Company]
 - m. <Insert manufacturer's name>

3. Body: Bronze or cast iron.
4. Internal Parts: Nonferrous.
5. Operator: Noncorrosive metal float.
6. Inlet Connection: **NPS 1/2 (DN 15)**.
7. Discharge Connection: **NPS 1/4 (DN 8)**.
8. CWP Rating: **150 psig (1035 kPa)**.
9. Maximum Operating Temperature: **240 deg F (116 deg C)**.

2.3 EXPANSION TANKS AND FITTINGS

A. Expansion Tanks with Direct Air/Water Interface:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AMTROL, Inc.]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Armstrong Fluid Technology]**
 - d. **[Bell & Gossett; a Xylem brand]**
 - e. **[Flo Fab Inc]**
 - f. **[Taco Comfort Solutions]**
 - g. **[WATTS; A Watts Water Technologies Company]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AMTROL, Inc.]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Armstrong Fluid Technology]**
 - d. **[Bell & Gossett; a Xylem brand]**
 - e. **[Flo Fab Inc]**
 - f. **[Taco Comfort Solutions]**
 - g. **[WATTS; A Watts Water Technologies Company]**
 - h. **<Insert manufacturer's name>**
3. Tank: Welded steel, rated for **125 psig (860 kPa)** working pressure and **375 deg F (191 deg C)** maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gauge glass. Tanks are factory tested after taps are fabricated and labeled in accordance with ASME BPVC, Section VIII, Division 1.
4. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless steel ball check, **100 gal. (379 L)** unit only; sized for expansion tank diameter. Provide tank fittings for **125 psig (860 kPa)** working pressure and **250 deg F (121 deg C)** maximum operating temperature.
5. Tank Drain Fitting: Brass body, nonferrous internal parts; **125 psig (860 kPa)** working pressure and **240 deg F (116 deg C)** maximum operating temperature; constructed to admit air to expansion tank, drain water, and close off system.
6. Gauge Glass: Full height with dual manual shutoff valves, **[3/4-inch- (20-mm-)]<Insert dimension>** diameter gauge glass, and slotted-metal glass guard.

B. Diaphragm-Type ASME Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Flo Fab Inc]**
 - e. **[Taco Comfort Solutions]**
 - f. **[WATTS; A Watts Water Technologies Company]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Flo Fab Inc]**
 - e. **[Taco Comfort Solutions]**
 - f. **[WATTS; A Watts Water Technologies Company]**
 - g. **<Insert manufacturer's name>**
3. Tank: Welded steel, rated for **125 psig (860 kPa)** working pressure and **375 deg F (191 deg C)** maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with ASME BPVC, Section VIII, Division 1.
4. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
5. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

C. Bladder-Type ASME Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Flo Fab Inc]**
 - e. **[Taco Comfort Solutions]**
 - f. **[WATTS; A Watts Water Technologies Company]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Flo Fab Inc]**

- e. **[Taco Comfort Solutions]**
 - f. **[WATTS; A Watts Water Technologies Company]**
 - g. **<Insert manufacturer's name>**
- 3. Tank: Welded steel, rated for **125 psig (860 kPa)** working pressure and **240 deg F (116 deg C)** maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with ASME BPVC, Section VIII, Division 1.
 - 4. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity. **[Field-replaceable bladder.]**
 - 5. **[Sight glass.]**
 - 6. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
- D. Diaphragm-Type Non-ASME Expansion Tanks:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Caleffi North America]**
 - e. **[Flamco; a division of AALBERTS Ind.]**
 - f. **[Flo Fab Inc]**
 - g. **[Taco Comfort Solutions]**
 - h. **[WATTS; A Watts Water Technologies Company]**
 - i. **[Zurn Industries, LLC]**
 - j. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Caleffi North America]**
 - e. **[Flamco; a division of AALBERTS Ind.]**
 - f. **[Flo Fab Inc]**
 - g. **[Taco Comfort Solutions]**
 - h. **[WATTS; A Watts Water Technologies Company]**
 - i. **[Zurn Industries, LLC]**
 - j. **<Insert manufacturer's name>**
 - 3. Tank: Carbon steel, non-ASME constructed, rated for minimum **100 psig (690 kPa)** working pressure at minimum **200 deg F (93 deg C)** maximum operating temperature.
 - 4. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
 - 5. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

2.4 AIR/DIRT SEPARATORS AND PURGERS

- A. Coalescing-Type Air and Dirt Separators:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Caleffi North America]**
 - e. **[Flamco; a division of AALBERTS Ind.]**
 - f. **[Flo Fab Inc]**
 - g. **[Nexus Valve, Inc.; Aalberts Hydronic Flow Control]**
 - h. **[Spirotherm, Inc.]**
 - i. **[Taco Comfort Solutions]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Caleffi North America]**
 - e. **[Flamco; a division of AALBERTS Ind.]**
 - f. **[Flo Fab Inc]**
 - g. **[Nexus Valve, Inc.; Aalberts Hydronic Flow Control]**
 - h. **[Spirotherm, Inc.]**
 - i. **[Taco Comfort Solutions]**
 - j. **<Insert manufacturer's name>**
3. Tank: Fabricated steel tank; ASME constructed and stamped for **125 psig (862 kPa)** working pressure and **270 deg F (130 deg C)** maximum operating temperature.
4. Coalescing Medium: **[Copper][Stainless steel]<Insert material>**.
5. Air Vent: Threaded to top of separator.
6. Inline Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; Class 150 flanged connections for **NPS 2-1/2 (DN 65)** and larger.
7. Blowdown Connection: Threaded to bottom of separator.
8. Size: Match system flow capacity.

B. Tangential-Type Air Separators:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Flamco; a division of AALBERTS Ind.]**
 - e. **[Flo Fab Inc]**
 - f. **[Nexus Valve, Inc.; Aalberts Hydronic Flow Control]**
 - g. **[Spirotherm, Inc.]**
 - h. **[Taco Comfort Solutions]**

- i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Flamco; a division of AALBERTS Ind.]**
 - e. **[Flo Fab Inc]**
 - f. **[Nexus Valve, Inc.; Aalberts Hydronic Flow Control]**
 - g. **[Spirotherm, Inc.]**
 - h. **[Taco Comfort Solutions]**
 - i. **<Insert manufacturer's name>**
3. Tank: Welded steel; ASME constructed and labeled for **125 psig (860 kPa)** minimum working pressure and **375 deg F (191 deg C)** maximum operating temperature.
4. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
5. Tangential Inlet and Outlet Connections: Threaded for **NPS 2 (DN 50)** and smaller; flanged connections for **NPS 2-1/2 (DN 65)** and larger.
6. Blowdown Connection: Threaded.
7. Size: Match system flow capacity.
- C. In-Line Air Separators:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Caleffi North America]**
 - e. **[Flamco; a division of AALBERTS Ind.]**
 - f. **[Flo Fab Inc]**
 - g. **[Spirotherm, Inc.]**
 - h. **[Taco Comfort Solutions]**
 - i. **[WATTS; A Watts Water Technologies Company]**
 - j. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AMTROL, Inc.]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Caleffi North America]**
 - e. **[Flamco; a division of AALBERTS Ind.]**
 - f. **[Flo Fab Inc]**
 - g. **[Spirotherm, Inc.]**
 - h. **[Taco Comfort Solutions]**
 - i. **[WATTS; A Watts Water Technologies Company]**

j. <Insert manufacturer's name>

3. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
4. Maximum Working Pressure: Up to **175 psig (1207 kPa)**.
5. Maximum Operating Temperature: Up to **300 deg F (149 deg C)**.

D. Air Purgers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Bell & Gossett; a Xylem brand]**
 - b. **[Griswold Controls, LLC]**
 - c. **[Spirotherm, Inc.]**
 - d. **[Taco Comfort Solutions]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bell & Gossett; a Xylem brand]**
 - b. **[Griswold Controls, LLC]**
 - c. **[Spirotherm, Inc.]**
 - d. **[Taco Comfort Solutions]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **<Insert manufacturer's name>**
3. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
4. Maximum Working Pressure: **150 psig (1035 kPa)**.
5. Maximum Operating Temperature: **250 deg F (121 deg C)**.

2.5 STRAINERS

A. Y-Pattern Strainers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[ASC Engineered Solutions]**
 - c. **[Caleffi North America]**
 - d. **[Flexicraft Industries]**
 - e. **[Flo Fab Inc]**
 - f. **[FNW; Ferguson Enterprises, Inc.]**
 - g. **[Griswold Controls, LLC]**
 - h. **[Hays Fluid Controls]**

- i. [Keckley Company]
 - j. [Metraflex Company (The)]
 - k. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - l. [Titan Flow Control, Inc.]
 - m. [Victaulic Company]
 - n. [WATTS; A Watts Water Technologies Company]
 - o. [Zurn Industries, LLC]
 - p. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [ASC Engineered Solutions]
 - c. [Caleffi North America]
 - d. [Flexicraft Industries]
 - e. [Flo Fab Inc]
 - f. [FNW; Ferguson Enterprises, Inc.]
 - g. [Griswold Controls, LLC]
 - h. [Hays Fluid Controls]
 - i. [Keckley Company]
 - j. [Metraflex Company (The)]
 - k. [Nexus Valve, Inc.; Aalberts Hydronic Flow Control]
 - l. [Titan Flow Control, Inc.]
 - m. [Victaulic Company]
 - n. [WATTS; A Watts Water Technologies Company]
 - o. [Zurn Industries, LLC]
 - p. <Insert manufacturer's name>
3. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
4. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
5. Strainer Screen: Stainless steel, [20][40][60]-mesh strainer, or perforated stainless steel basket.
6. CWP Rating: **125 psig (860 kPa)**.

B. Basket Strainers:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Flexicraft Industries]
 - b. [Flo Fab Inc]
 - c. [Keckley Company]
 - d. [Metraflex Company (The)]
 - e. [Titan Flow Control, Inc.]
 - f. [WATTS; A Watts Water Technologies Company]
 - g. [Zurn Industries, LLC]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Flexicraft Industries]
- b. [Flo Fab Inc]
- c. [Keckley Company]
- d. [Metraflex Company (The)]
- e. [Titan Flow Control, Inc.]
- f. [WATTS; A Watts Water Technologies Company]
- g. [Zurn Industries, LLC]
- h. <Insert manufacturer's name>

- 3. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
- 4. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
- 5. Strainer Screen: [40][60]-mesh startup strainer and perforated stainless steel basket with 50 percent free area.
- 6. CWP Rating: **125 psig (860 kPa)**.

C. T-Pattern Strainers:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [ASC Engineered Solutions]
 - c. [Keckley Company]
 - d. [WATTS; A Watts Water Technologies Company]
 - e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [ASC Engineered Solutions]
 - c. [Keckley Company]
 - d. [WATTS; A Watts Water Technologies Company]
 - e. <Insert manufacturer's name>
- 3. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
- 4. End Connections: Grooved ends.
- 5. Strainer Screen: [40][60]-mesh startup strainer and perforated stainless steel basket with 57 percent free area.
- 6. CWP Rating: **750 psig (5170 kPa)**.

2.6 FLEXIBLE CONNECTORS

A. Stainless Steel Bellows, Flexible Connectors:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Flexicraft Industries]**
 - b. **[Flo Fab Inc]**
 - c. **[Metraflex Company (The)]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Flexicraft Industries]**
 - b. **[Flo Fab Inc]**
 - c. **[Metraflex Company (The)]**
 - d. **<Insert manufacturer's name>**
 3. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
 4. End Connections: Threaded or flanged to match equipment connected.
 5. Performance: Capable of **3/4-inch (20-mm)** misalignment.
 6. CWP Rating: **150 psig (1035 kPa)**.
 7. Maximum Operating Temperature: **250 deg F (121 deg C)**.
- B. Spherical, Rubber, Flexible Connectors:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Flexicraft Industries]**
 - b. **[Flo Fab Inc]**
 - c. **[Metraflex Company (The)]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Flexicraft Industries]**
 - b. **[Flo Fab Inc]**
 - c. **[Metraflex Company (The)]**
 - d. **<Insert manufacturer's name>**
 3. Body: Fiber-reinforced rubber body.
 4. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
 5. Performance: Capable of misalignment.
 6. CWP Rating: **150 psig (1035 kPa)**.
 7. Maximum Operating Temperature: **250 deg F (121 deg C)**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine all piping specialties for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

- B. Examine threads on all devices for form and cleanliness.
- C. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- D. Do not attempt to repair defective piping specialties; replace with new devices. Remove defective piping specialties from site.

3.2 INSTALLATION OF VALVES

- A. Install calibrated-orifice balancing valve at each branch connection to return main.
- B. Install calibrated-orifice, balancing valve in the return pipe of each heating or cooling terminal.
- C. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.
- D. Install pressure-relief and safety-relief valves at hot-water generators and elsewhere as required by ASME BPVC. Pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME BPVC, Section VIII, Division 1, for installation requirements.

3.3 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.
 - 1. Provide air outlet drain line full size of air outlet to floor drain or to other point indicated on Drawings.
- C. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- D. Install in-line air separators in pump suction. Install drain valve on air separators **NPS 2 (DN 50)** and larger.
- E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve full size of separator outlet; extend full size to nearest floor drain.
- F. Install expansion tanks having direct air/water interface above the air separator or air purger. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
 - 1. Install tank fittings that are shipped loose.
 - 2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, and fittings, plus tank full of water. Do not overload building components and structural members.
 - 3. Install piping from air separator or air purger to expansion tank with a 2 percent upward slope toward tank to avoid air entrapment.
- G. Install diaphragm- or bladder-type expansion tanks on the floor.



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

- H. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 23 21 16 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 21 16 00	21 05 00 00	Common Work Results for Fire Suppression
23 21 16 00	22 05 00 00	Common Work Results for Plumbing
23 21 16 00	22 15 13 00	General-Service Compressed-Air Piping
23 21 16 00	23 05 00 00	Common Work Results for HVAC
23 21 16 00	22 12 23 26	Facility Fuel-Oil Piping
23 21 16 00	23 21 13 00	Hydronic Piping
23 21 16 00	23 21 00 00	Underground Hydronic Piping
23 21 16 00	23 21 23 00	Hydronic Pumps
23 21 16 00	22 11 16 00d	Steam And Condensate Piping
23 21 16 00	23 23 00 00	Refrigerant Piping
23 21 16 00	23 43 00 00	Electronic Air Cleaners



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 21 23 00 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Close-coupled, end-suction centrifugal pumps.
3. Separately coupled, horizontally mounted, in-line centrifugal pumps.
4. Separately coupled, vertically mounted, in-line centrifugal pumps.
5. Separately coupled, base-mounted, end-suction centrifugal pumps.
6. Separately coupled, base-mounted, double-suction centrifugal pumps.
7. Separately coupled, vertically mounted, double-suction centrifugal pumps.
8. Separately coupled, vertically mounted, turbine centrifugal pumps.
9. Wet-rotor pumps.
10. Automatic condensate pump units.

1.2 DEFINITIONS

- A. ECM: Electronically commutated motor.
- B. EPDM: Ethylene propylene diene monomer.
- C. EPR: Ethylene propylene rubber.
- D. FKM: Fluoroelastomer polymer.
- E. HI: Hydraulic Institute.
- F. NBR: Nitrile rubber or Buna-N.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pump.

1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
2. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittals: For each pump.



1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - a. Design Calculations: Calculate requirements for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.
 - b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Seismic Qualification Data: Certificates for pumps, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Mechanical Seals: **[One]<Insert number>** mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[**and seismic restraints**].
- C. Seismic Performance: Pumps shall withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
2. Component Importance Factor: [1.5][1.0].
3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>.**

2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

1. [American-Marsh Pumps]
2. [Armstrong Fluid Technology]
3. [Aurora Pump; Pentair Ltd.]
4. [Crane Pumps & Systems]
5. [Flowserve Corporation]
6. [GRUNDFOS CBS Inc.]
7. [ITT Corporation]
8. [Mepco, LLC]
9. [PACO Pumps; Grundfos Pumps Corporation, USA]
10. [Patterson Pump Company; a Gorman-Rupp company]
11. [Peerless Pump Company]
12. [Taco Comfort Solutions]
13. [Thrush Co. Inc.]
14. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [American-Marsh Pumps]
2. [Armstrong Fluid Technology]
3. [Aurora Pump; Pentair Ltd.]
4. [Crane Pumps & Systems]
5. [Flowserve Corporation]
6. [GRUNDFOS CBS Inc.]
7. [ITT Corporation]
8. [Mepco, LLC]
9. [PACO Pumps; Grundfos Pumps Corporation, USA]
10. [Patterson Pump Company; a Gorman-Rupp company]
11. [Peerless Pump Company]
12. [Taco Comfort Solutions]
13. [Thrush Co. Inc.]
14. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain pumps from single source from single manufacturer.

- D. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

- E. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet[, **replaceable**

2. **bronze wear rings,**] and threaded [**companion-flange**][**union-end**] connections.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft Sleeve: [**Bronze**][**Type 304 stainless steel**].
4. Pump Stub Shaft: [**Type 304**][**Type 316**] stainless steel.
5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and [**NBR**][**EPDM**][**FKM**]<Insert material> rubber bellows and gasket. Include water slinger on shaft between motor and seal.
6. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.

F. Shaft Coupling: Rigid, axially-split spacer coupling to allow service of pump seal without disturbing pump or motor.

G. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

1. Enclosure : [**Totally enclosed, fan cooled**]<Insert enclosure type>.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. [**Single**][**Variable**]-speed motor.
6. Provide integral pump motor variable-speed controller.
7. <Insert unique motor characteristics>.

H. Capacities and Characteristics:

1. Capacity: <Insert gpm (L/s)>.
2. Total Dynamic Head: <Insert feet (kPa)>.
3. Maximum Operating Pressure: [**175 psig (1204 kPa)**][**250 psig (1720 kPa)**]<Insert value>.
4. Maximum Continuous Operating Temperature: [**225 deg F (107 deg C)**][**250 deg F (120 deg C)**]<Insert temperature>.
5. Inlet and Outlet Size: <Insert NPS (DN)>.
6. Impeller Size: <Insert inches (mm)>.
7. Motor Speed: <Insert rpm>.
8. Motor Horsepower: <Insert value>.
9. Electrical Characteristics:
 - a. Volts: [**120**][**240**][**208**][**460**]<Insert value> V.
 - b. Phase: [**Single**][**Three**].
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: <Insert value> A.
 - e. Minimum Circuit Ampacity: <Insert value> A.
 - f. Maximum Overcurrent Protection: <Insert value> A.

2.3 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

1. [American-Marsh Pumps]
 2. [Armstrong Fluid Technology]
 3. [Aurora Pump; Pentair Ltd.]
 4. [Buffalo Pumps, Inc]
 5. [Crane Pumps & Systems]
 6. [Flowserve Corporation]
 7. [GRUNDFOS CBS Inc.]
 8. [ITT Corporation]
 9. [Lancaster Pump]
 10. [Mepco, LLC]
 11. [PACO Pumps; Grundfos Pumps Corporation, USA]
 12. [Patterson Pump Company; a Gorman-Rupp company]
 13. [Peerless Pump Company]
 14. [Scot Pump; a division of Ardox Corporation]
 15. [Taco Comfort Solutions]
 16. [Thrush Co. Inc.]
 17. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. [American-Marsh Pumps]
 2. [Armstrong Fluid Technology]
 3. [Aurora Pump; Pentair Ltd.]
 4. [Buffalo Pumps, Inc]
 5. [Crane Pumps & Systems]
 6. [Flowserve Corporation]
 7. [GRUNDFOS CBS Inc.]
 8. [ITT Corporation]
 9. [Lancaster Pump]
 10. [Mepco, LLC]
 11. [PACO Pumps; Grundfos Pumps Corporation, USA]
 12. [Patterson Pump Company; a Gorman-Rupp company]
 13. [Peerless Pump Company]
 14. [Scot Pump; a division of Ardox Corporation]
 15. [Taco Comfort Solutions]
 16. [Thrush Co. Inc.]
 17. <Insert manufacturer's name>
- C. Source Limitations: Obtain pumps from single source from single manufacturer.
- D. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- E. Pump Construction:
1. Casing: Radially split, cast iron, with[**replaceable bronze wear rings,**] drain plug at bottom and air vent at top of volute, threaded gauge tappings at inlet and outlet, and [**threaded companion-flange**][**flanged**] connections.
 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
 3. Pump Shaft Sleeve: [**Bronze**][**Type 304 stainless steel**].
 4. Pump Stub Shaft: [**Type 304**][**Type 316**] stainless steel.
 5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a

stainless steel spring, and [NBR][EPDM][FKM] bellows and gasket. Include water slinger on shaft between motor and seal.

F. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

1. Enclosure: **[Totally enclosed, fan cooled]<Insert enclosure type>**.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. **[Single][Variable]**-speed motor.
6. Provide integral pump motor variable-speed controller.
7. **<Insert unique motor characteristics>**.

G. Capacities and Characteristics:

1. Capacity: **<Insert gpm (L/s)>**.
2. Total Dynamic Head: **<Insert feet (kPa)>**.
3. Maximum Operating Pressure: **[175 psig (1204 kPa)]<Insert value>**.
4. Maximum Continuous Operating Temperature: **[225 deg F (107 deg C)][250 deg F (120 deg C)]<Insert temperature>**.
5. Inlet and Outlet Size: **<Insert NPS (DN)>**.
6. Impeller Size: **<Insert inches (mm)>**.
7. Motor Speed: **<Insert rpm>**.
8. Motor Horsepower: **<Insert value>**.
9. Electrical Characteristics:
 - a. Volts: **[120][240][208][460]<Insert value> V**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value> A**.
 - e. Minimum Circuit Ampacity: **<Insert value> A**.
 - f. Maximum Overcurrent Protection: **<Insert value> A**.

2.4 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Armstrong Fluid Technology]**
2. **[Aurora Pump; Pentair Ltd.]**
3. **[Flowserve Corporation]**
4. **[ITT Corporation]**
5. **[Mepco, LLC]**
6. **[PACO Pumps; Grundfos Pumps Corporation, USA]**
7. **[Scot Pump; a division of Ardox Corporation]**
8. **[Taco Comfort Solutions]**
9. **[Thrush Co. Inc.]**
10. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's**

name; product name or designation> or comparable product by one of the following:

1. **[Armstrong Fluid Technology]**
2. **[Aurora Pump; Pentair Ltd.]**
3. **[Flowserve Corporation]**
4. **[ITT Corporation]**
5. **[Mepco, LLC]**
6. **[PACO Pumps; Grundfos Pumps Corporation, USA]**
7. **[Scot Pump; a division of Ardox Corporation]**
8. **[Taco Comfort Solutions]**
9. **[Thrush Co. Inc.]**
10. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain pumps from single source from single manufacturer.
- D. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- E. Pump Construction:
 1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, and threaded **[companion-flange][union-end]** connections.
 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: **[Carbon steel, with copper-alloy shaft sleeve][Type 304 stainless steel][Type 316 stainless steel]**.
 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and **[NBR][EPDM][FKM]<Insert material>** bellows and gasket.
 5. Pump Bearings: **[Permanently lubricated ball bearings][Grease lubricated ball bearings]**.
- F. Shaft Coupling: **[Molded-rubber insert with interlocking spider][Interlocking frame with interconnecting springs]** capable of absorbing vibration.
- G. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 1. Enclosure Type: **[Totally enclosed, fan cooled]<Insert enclosure type>**.
 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 5. **[Single][Variable]**-speed motor.
 6. Provide integral pump motor variable-speed controller.
 7. **<Insert unique motor characteristics>**.
- H. Capacities and Characteristics:
 1. Capacity: **<Insert gpm (L/s)>**.
 2. Total Dynamic Head: **<Insert feet (kPa)>**.
 3. Maximum Operating Pressure: **[175 psig (1204 kPa)][<Insert value>**.
 4. Maximum Continuous Operating Temperature: **[225 deg F (107 deg C)][250 deg F (120 deg C)][<Insert temperature>**.
 5. Inlet and Outlet Size: **<Insert NPS (DN)>**.
 6. Impeller Size: **<Insert inches (mm)>**.

7. Motor Speed: <Insert rpm>.
8. Motor Horsepower: <Insert value>.
9. Electrical Characteristics:
 - a. Volts: [120][240][208][460]<Insert value> V.
 - b. Phase: [Single][Three].
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: <Insert value> A.
 - e. Minimum Circuit Ampacity: <Insert value> A.
 - f. Maximum Overcurrent Protection: <Insert value> A.

2.5 SEPARATELY COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Armstrong Fluid Technology]
2. [Aurora Pump; Pentair Ltd.]
3. [Crane Pumps & Systems]
4. [Flowserve Corporation]
5. [ITT Corporation]
6. [Mepco, LLC]
7. [PACO Pumps; Grundfos Pumps Corporation, USA]
8. [Patterson Pump Company; a Gorman-Rupp company]
9. [Peerless Pump Company]
10. [Taco Comfort Solutions]
11. [Thrush Co. Inc.]
12. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Armstrong Fluid Technology]
2. [Aurora Pump; Pentair Ltd.]
3. [Crane Pumps & Systems]
4. [Flowserve Corporation]
5. [ITT Corporation]
6. [Mepco, LLC]
7. [PACO Pumps; Grundfos Pumps Corporation, USA]
8. [Patterson Pump Company; a Gorman-Rupp company]
9. [Peerless Pump Company]
10. [Taco Comfort Solutions]
11. [Thrush Co. Inc.]
12. <Insert manufacturer's name>

- C. Source Limitations: Obtain pumps from single source from single manufacturer.
- D. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.
- E. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet[, **replaceable bronze wear rings,**] and threaded [**companion-flange**][**union-end**] connections.
 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: [**Carbon steel, with copper-alloy shaft sleeve**][**Type 304 stainless steel**][**Type 316 stainless steel**].
 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and [**NBR**][**EPDM**][**FKM**]**<Insert material>** bellows and gasket.
- F. Shaft Coupling: [**Molded-rubber insert with interlocking spider**][**Interlocking frame with interconnecting springs**] capable of absorbing vibration.
- G. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
1. Enclosure: [**Totally enclosed, fan cooled**]**<Insert enclosure type>**.
 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 5. [**Single**][**Variable**]-speed motor.
 6. Provide integral pump motor variable-speed controller.
 7. **<Insert unique motor characteristics>**.
- H. Capacities and Characteristics:
1. Capacity: **<Insert gpm (L/s)>**.
 2. Total Dynamic Head: **<Insert feet (kPa)>**.
 3. Maximum Operating Pressure: [**175 psig (1204 kPa)**][**250 psig (1720 kPa)**]**<Insert value>**.
 4. Maximum Continuous Operating Temperature: [**225 deg F (107 deg C)**][**250 deg F (120 deg C)**]**<Insert temperature>**.
 5. Inlet and Outlet Size: **<Insert NPS (DN)>**.
 6. Impeller Size: **<Insert inches (mm)>**.
 7. Motor Speed: **<Insert rpm>**.
 8. Motor Horsepower: **<Insert value>**.
 9. Electrical Characteristics:
 - a. Volts: [**120**][**240**][**208**][**460**]**<Insert value>** V.
 - b. Phase: [**Single**][**Three**].
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value>** A.
 - e. Minimum Circuit Ampacity: **<Insert value>** A.
 - f. Maximum Overcurrent Protection: **<Insert value>** A.

2.6 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
1. [**American-Marsh Pumps**]
 2. [**Armstrong Fluid Technology**]
 3. [**Aurora Pump; Pentair Ltd.**]

4. [Buffalo Pumps, Inc]
5. [Crane Pumps & Systems]
6. [Flowserve Corporation]
7. [ITT Corporation]
8. [Mepco, LLC]
9. [PACO Pumps; Grundfos Pumps Corporation, USA]
10. [Peerless Pump Company]
11. [Scot Pump; a division of Ardox Corporation]
12. [Taco Comfort Solutions]
13. [Thrush Co. Inc.]
14. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [American-Marsh Pumps]
2. [Armstrong Fluid Technology]
3. [Aurora Pump; Pentair Ltd.]
4. [Buffalo Pumps, Inc]
5. [Crane Pumps & Systems]
6. [Flowserve Corporation]
7. [ITT Corporation]
8. [Mepco, LLC]
9. [PACO Pumps; Grundfos Pumps Corporation, USA]
10. [Peerless Pump Company]
11. [Scot Pump; a division of Ardox Corporation]
12. [Taco Comfort Solutions]
13. [Thrush Co. Inc.]
14. <Insert manufacturer's name>

C. Source Limitations: Obtain pumps from single source from single manufacturer.

D. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump with flexible shaft coupling as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

E. Pump Construction:

1. Casing: Radially split, cast iron, with[**replaceable bronze wear rings,**] threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and [b>threaded companion-flange][flanged] connections.[**Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring realignment of pump and motor shaft.**]
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: [Carbon steel, with copper-alloy shaft sleeve][Type 304 stainless steel][Type 316 stainless steel].
4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and [NBR][EPDM][FKM]<Insert material> bellows and gasket.
5. Seal, Packing Type: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

- F. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. **[Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor][EPDM coupling sleeve for variable-speed applications].**
- G. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
- H. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
- I. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 1. Enclosure: **[Totally enclosed, fan cooled]<Insert enclosure type>.**
 - 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - 5. **[Single][Variable]-speed motor.**
 - 6. Provide integral pump motor variable-speed controller.
 - 7. **<Insert unique motor characteristics>.**
- J. Capacities and Characteristics:
 - 1. Capacity: **<Insert gpm (L/s)>.**
 - 2. Total Dynamic Head: **<Insert feet (kPa)>.**
 - 3. Maximum Operating Pressure: **[175 psig (1204 kPa)][250 psig (1720 kPa)]<Insert value>.**
 - 4. Maximum Continuous Operating Temperature: **[225 deg F (107 deg C)][250 deg F (120 deg C)]<Insert temperature>.**
 - 5. Inlet and Outlet Size: **<Insert NPS (DN)>.**
 - 6. Impeller Size: **<Insert inches (mm)>.**
 - 7. Motor Speed: **<Insert rpm>.**
 - 8. Motor Horsepower: **<Insert value>.**
 - 9. Electrical Characteristics:
 - a. Volts: **[120][240][208][460]<Insert value> V.**
 - b. Phase: **[Single][Three].**
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value> A.**
 - e. Minimum Circuit Ampacity: **<Insert value> A.**
 - f. Maximum Overcurrent Protection: **<Insert value> A.**

2.7 SEPARATELY COUPLED, BASE-MOUNTED, DOUBLE-SUCTION CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[American-Marsh Pumps]**
 - 2. **[Armstrong Fluid Technology]**
 - 3. **[Aurora Pump; Pentair Ltd.]**
 - 4. **[Buffalo Pumps, Inc]**
 - 5. **[Crane Pumps & Systems]**
 - 6. **[Flowserve Corporation]**

7. [GRUNDFOS CBS Inc.]
 8. [ITT Corporation]
 9. [PACO Pumps; Grundfos Pumps Corporation, USA]
 10. [Patterson Pump Company; a Gorman-Rupp company]
 11. [Peerless Pump Company]
 12. [Scot Pump; a division of Ardox Corporation]
 13. [Taco Comfort Solutions]
 14. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [American-Marsh Pumps]
 2. [Armstrong Fluid Technology]
 3. [Aurora Pump; Pentair Ltd.]
 4. [Buffalo Pumps, Inc]
 5. [Crane Pumps & Systems]
 6. [Flowserve Corporation]
 7. [GRUNDFOS CBS Inc.]
 8. [ITT Corporation]
 9. [PACO Pumps; Grundfos Pumps Corporation, USA]
 10. [Patterson Pump Company; a Gorman-Rupp company]
 11. [Peerless Pump Company]
 12. [Scot Pump; a division of Ardox Corporation]
 13. [Taco Comfort Solutions]
 14. <Insert manufacturer's name>
- C. Source Limitations: Obtain pumps from single source from single manufacturer.
- D. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.
- E. Pump Construction:
1. Casing: [Radially][Horizontally] split, cast iron, with[replaceable bronze wear rings,] threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and ASME B16.1, [Class 125][Class 250] flanges.[Casing supports shall allow removal and replacement of impeller without disconnecting piping.]
 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: [Type 304][Type 316] stainless steel.
 4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and [NBR][EPDM][FKM]<Insert material> bellows and gasket.
 5. Seal, Packing Type: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.
- F. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. [Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor][EPDM coupling sleeve for variable-speed applications].
- G. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

- H. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
- I. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 1. Enclosure: **[Totally enclosed, fan cooled]<Insert enclosure type>**.
 - 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - 5. **[Single][Variable]**-speed motor.
 - 6. Provide integral pump motor variable-speed controller.
 - 7. **<Insert unique motor characteristics>**.
- J. Capacities and Characteristics:
 - 1. Capacity: **<Insert gpm (L/s)>**.
 - 2. Total Dynamic Head: **<Insert feet (kPa)>**.
 - 3. Maximum Operating Pressure: **[175 psig (1204 kPa)][250 psig (1720 kPa)]<Insert value>**.
 - 4. Maximum Continuous Operating Temperature: **[225 deg F (107 deg C)][250 deg F (120 deg C)]<Insert temperature>**.
 - 5. Inlet and Outlet Size: **<Insert NPS (DN)>**.
 - 6. Impeller Size: **<Insert inches (mm)>**.
 - 7. Motor Speed: **<Insert rpm>**.
 - 8. Motor Horsepower: **<Insert value>**.
 - 9. Electrical Characteristics:
 - a. Volts: **[120][240][208][460]<Insert value> V**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value> A**.
 - e. Minimum Circuit Ampacity: **<Insert value> A**.
 - f. Maximum Overcurrent Protection: **<Insert value> A**.

2.8 SEPARATELY COUPLED, VERTICALLY MOUNTED, DOUBLE-SUCTION CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[American-Marsh Pumps]**
 - 2. **[Armstrong Fluid Technology]**
 - 3. **[Aurora Pump; Pentair Ltd.]**
 - 4. **[Buffalo Pumps, Inc]**
 - 5. **[Flowserve Corporation]**
 - 6. **[GRUNDFOS CBS Inc.]**
 - 7. **[ITT Corporation]**
 - 8. **[Mepco, LLC]**
 - 9. **[PACO Pumps; Grundfos Pumps Corporation, USA]**
 - 10. **[Peerless Pump Company]**
 - 11. **[Pentair Water Commercial Pool and Aquatics]**
 - 12. **[Taco Comfort Solutions]**
 - 13. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[American-Marsh Pumps]**
 2. **[Armstrong Fluid Technology]**
 3. **[Aurora Pump; Pentair Ltd.]**
 4. **[Buffalo Pumps, Inc]**
 5. **[Flowserve Corporation]**
 6. **[GRUNDFOS CBS Inc.]**
 7. **[ITT Corporation]**
 8. **[Mepco, LLC]**
 9. **[PACO Pumps; Grundfos Pumps Corporation, USA]**
 10. **[Peerless Pump Company]**
 11. **[Pentair Water Commercial Pool and Aquatics]**
 12. **[Taco Comfort Solutions]**
 13. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain pumps from single source from single manufacturer.
- D. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.
- E. Pump Construction:
1. Casing: Radially split, cast iron, with **[replaceable bronze wear rings,]** threaded gauge tappings at inlet and outlet, drain plug at bottom of volute, mounting support, and ASME B16.1, **[Class 125][Class 250]** flanges.
 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: **[Type 304 stainless steel][Type 316 stainless steel]<Insert material>**.
 4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and **[NBR][EPDM][FKM]<Insert material>** bellows and gasket.
 5. Seal, Packing Type: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.
- F. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration.
- G. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
1. Enclosure: **[Totally enclosed, fan cooled]<Insert enclosure type>**.
 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 5. **[Single][Variable]-speed motor.**
 6. Provide integral pump motor variable-speed controller.
 7. **<Insert unique motor characteristics>**.
- H. Capacities and Characteristics:

1. Capacity: **<Insert gpm (L/s)>**.
2. Total Dynamic Head: **<Insert feet (kPa)>**.
3. Maximum Operating Pressure: **[175 psig (1204 kPa)][250 psig (1720 kPa)]<Insert value>**.
4. Maximum Continuous Operating Temperature: **[225 deg F (107 deg C)][250 deg F (120 deg C)]<Insert temperature>**.
5. Inlet and Outlet Size: **<Insert NPS (DN)>**.
6. Impeller Size: **<Insert inches (mm)>**.
7. Motor Speed: **<Insert rpm>**.
8. Motor Horsepower: **<Insert value>**.
9. Electrical Characteristics:
 - a. Volts: **[120][240][208][460]<Insert value> V**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value> A**.
 - e. Minimum Circuit Ampacity: **<Insert value> A**.
 - f. Maximum Overcurrent Protection: **<Insert value> A**.

2.9 SEPARATELY COUPLED, VERTICALLY MOUNTED, TURBINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[American-Marsh Pumps]**
 2. **[Flowserve Corporation]**
 3. **[Peerless Pump Company]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[American-Marsh Pumps]**
 2. **[Flowserve Corporation]**
 3. **[Peerless Pump Company]**
 4. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain pumps from single source from single manufacturer.
- D. Description: Factory-assembled and -tested, **[single-stage][multistage]**, centrifugal, impeller-between-bearings, end-suction pump as defined in HI 2.1-2.2 and HI 2.3; designed for installation with pump and motor shafts mounted vertically and projecting into a sump.
- E. Pump Construction:
 1. Pump Bowl: Cast iron, with **[cone][basket]** strainer[, **replaceable bronze wear ring,**] and suction bell.**[Water passages of intermediate bowls shall be coated with porcelain enamel.]**
 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced and keyed to shaft. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: **[Carbon][Type 304 stainless][Type 316 stainless]** steel sized in accordance with manufacturer's written instructions.
 4. Pump Bearings: Water-lubricated bronze and rubber sleeve bearings in cast-iron housing.
 5. Pump Column: ASTM A53/A53M, Grade B steel pipe.
 6. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and **[NBR][EPDM][FKM]** bellows and gasket. Include water

7. slinger on shaft between motor and seal.
7. Seal, Packing Type: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.

F. Shaft Coupling: Keyed with locking collets.

G. Discharge Head: ASME B16.1, **[Class 125][Class 250]** discharge flange with threaded gauge tapping. Top of discharge head shall have a registered fit to accurately locate the driver.

H. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

1. Enclosure: **[Totally enclosed, fan cooled]<Insert enclosure type>**.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. **[Single][Variable]**-speed motor.
6. Provide integral pump motor variable-speed controller.
7. **<Insert unique motor characteristics>**.

I. Capacities and Characteristics:

1. Capacity: **<Insert gpm (L/s)>**.
2. Total Dynamic Head: **<Insert feet (kPa)>**.
3. Minimum Static Head: **<Insert feet (kPa)>**.
4. Maximum Operating Pressure: **[175 psig (1204 kPa)][<Insert value>**.
5. Maximum Continuous Operating Temperature: **[200 deg F (93 deg C)][<Insert temperature>**.
6. Outlet Size: **<Insert NPS (DN)>**.
7. Impeller Size: **<Insert inches (mm)>**.
8. Motor Speed: **<Insert rpm>**.
9. Motor Horsepower: **<Insert value>**.
10. Electrical Characteristics:
 - a. Volts: **[120][240][208][460]<Insert value> V**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value> A**.
 - e. Minimum Circuit Ampacity: **<Insert value> A**.
 - f. Maximum Overcurrent Protection: **<Insert value> A**.

2.10 WET-ROTOR PUMPS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Armstrong Fluid Technology]**
2. **[Flowserve Corporation]**
3. **[GRUNDFOS CBS Inc.]**
4. **[ITT Corporation]**
5. **[Taco Comfort Solutions]**

6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Armstrong Fluid Technology]**
 2. **[Flowserve Corporation]**
 3. **[GRUNDFOS CBS Inc.]**
 4. **[ITT Corporation]**
 5. **[Taco Comfort Solutions]**
 6. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain pumps from single source from single manufacturer.
- D. Description: Factory-assembled and -tested, wet-rotor pump. Pump and motor to form an integral unit with bearings lubricated by the pumped liquid.
- E. Pump Construction:
1. Body: **[100 percent lead-free bronze][Type 304 stainless steel][Cast iron]**.
 2. Impeller: **[Polypropylene][Noryl][Type 304 stainless steel]**.
 3. Pump Shaft: **[Ceramic][Type 304 stainless steel][Type 316 stainless steel]**.
 4. Bearings. Double-sintered carbon.
- F. Motor: **[Single][Three][Variable]** speed.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Efficiency: Premium Efficiency.
 - b. NEMA Design: **<Insert designation>**.
 - c. Service Factor: **<Insert value>**.
 3. Integral pump motor variable-speed control.
 4. ECM.
- G. Capacities and Characteristics:
1. Capacity: **<Insert gpm (L/s)>**.
 2. Total Dynamic Head: **<Insert feet (kPa)>**.
 3. Maximum Operating Pressure: **[150 psig (1132 kPa)]<Insert value>**.
 4. Maximum Continuous Operating Temperature: **[225 deg F (107 deg C)][230 deg F (111 deg C)]<Insert temperature>**.
 5. Inlet and Outlet Size: **<Insert NPS (DN)>**.
 6. Impeller Size: **<Insert inches (mm)>**.
 7. Motor Speed: **<Insert rpm>**.
 8. Motor Horsepower: **<Insert value>**.
 9. Electrical Characteristics:
 - a. Volts: **[120]<Insert value> V**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value> A**.
 - e. Minimum Circuit Ampacity: **<Insert value> A**.

- f. Maximum Overcurrent Protection: **<Insert value> A.**

2.11 AUTOMATIC CONDENSATE PUMP UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Beckett Corporation]**
2. **[Crane Pumps & Systems]**
3. **[GRUNDFOS CBS Inc.]**
4. **[Hartell Pumps; Milton Roy]**
5. **[Little Giant; a brand of Franklin Electric Co., Inc.]**
6. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Beckett Corporation]**
2. **[Crane Pumps & Systems]**
3. **[GRUNDFOS CBS Inc.]**
4. **[Hartell Pumps; Milton Roy]**
5. **[Little Giant; a brand of Franklin Electric Co., Inc.]**
6. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain pump units from single source from single manufacturer.

- D. Description: Packaged units with corrosion-resistant pump, **[aluminum][plastic]** tank with cover, and automatic controls. Collects and removes condensate from fan coil units, air handling units, condensing boilers, and similar components. Include factory- or field-installed check valve and **72-inch- (1800-mm-)** minimum, electrical power cord with plug.

- E. Capacities and Characteristics:

1. Tank Capacity: **<Insert gal (L)>**.
2. Pump Capacity: **<Insert gpm (L/s)>**.
3. Maximum Lift: **<Insert feet (m)>**.
4. Motor Horsepower: **<Insert value>**.
5. Electrical Characteristics:
 - a. Volts: **[120]<Insert value> V.**
 - b. Phase: Single.
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: **<Insert value> A.**
 - e. Minimum Circuit Ampacity: **<Insert value> A.**
 - f. Maximum Overcurrent Protection: **<Insert value> A.**

2.12 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser:

1. Angle pattern.
2. **[175-psig (1204-kPa)][300-psig (2060-kPa)]** pressure rating, **[cast][ductile]-iron** body and end

- cap, pump-inlet fitting.
3. Bronze 16-mesh wire startup and **[bronze][Type 304 stainless steel]** permanent strainers with **3/16-inch (4.8-mm) perforations and 51 percent open area**.
4. **[Bronze][Carbon steel][Type 304 stainless steel]** straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

B. Triple-Duty Valve:

1. Angle or straight pattern.
2. **[175-psig (1204-kPa)][300-psig (2060-kPa)]** pressure rating, **[cast][ductile]-iron** body, pump-discharge fitting.
3. Valve with multi-turn stem and memory stop to allow valve to be returned to its original position after shutoff.
4. Brass valve disc with EPDM rubber seat.
5. Type 304 stainless steel valve stem.
6. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
7. Brass gauge ports with integral check valve and orifice for flow measurement.

2.13 INTEGRAL PUMP MOTOR VARIABLE-SPEED CONTROLLERS

A. Where specified or scheduled, provide pumps with an integral pump motor speed controller.

1. Motor: Operates as constant- or variable-speed pump with speed regulated by an integrated variable-speed drive.
2. Integrated Pump Controller: Supports direct communication with the building management system (BMS) with built-in support for the following protocols: **[Modbus RTU][BACnet MS/TP][Metasys N2]**.
3. Commissioning and pump set up access to pump controls via the following:
 - a. A web interface (data exchange).
 - b. A user interface located on the face of speed controller to adjust modes and mode values.
 - c. An electronic display that reads real-time mode set values, flow, head, speed, and power and that locks out unauthorized adjustment of pump.
4. Provide electronics with "Auto" as factory default but slope of the proportional curve will automatically match the required system curve, constant pressure control (delta-p/c), variable differential pressure control (delta-p/v), constant curve duty (uncontrolled pump), and rpm regulation. RPM (speed) regulation can be accomplished by the following:
 - a. Manual (via user interface or HTML).
 - b. Remote via 0 to 10 V dc.
 - c. Data protocol communications with the BMS.
5. Pump Electronics: Standard with multiple digital inputs and one external digital output to be available for additional mechanical room control and pump status monitoring.
6. Controller: Mounted on or adjacent to the motor. Provide enclosure rated to UL Type 12.
7. Electronically Protected Pumps: Rated for continuous duty and with built-in startup circuit. Provide overcurrent, line surge and current limit protection, thermal monitoring, heat sink status and over temperature protection.
8. Pump capable of being monitored continuously via integrated Internet link.
9. Integrated pump controller system to have the following features:
 - a. Controller software shall be capable of sensorless control in variable-volume systems without need for pump-mounted (internal/external) or remotely mounted differential

- pressure sensor.
- b. Integrated Pump Controller Sensorless Control: Operates under Quadratic Pressure Control (QPC) to ensure that head reduction with reducing flow conforms to quadratic control curve.
- c. Controller:
 - 1) Minimum head of 40 percent of design duty head.
 - 2) User-adjustable control mode settings and minimum/maximum head set points using built-in programming interface.
- d. Controller Integrated Control Software:
 - 1) Capable of controlling pump performance for non-overloading power at every point of operation.
 - 2) Capable of maintaining flow rate data.

2.14 ELECTRONICALLY COMMUTATED MOTOR (ECM)

- A. Provide pumps so they are specified or scheduled with ECM.
 - 1. Synchronous, constant torque, ECM with permanent magnet rotor. Rotor magnets to be time-stable, nontoxic ceramic magnets (Sr-Fe).
 - 2. Driven by a frequency converter with an integrated power factor correction filter. Conventional induction motors will not be acceptable.
 - 3. Each motor with an integrated variable-frequency drive, tested as one unit by manufacturer.
 - 4. Motor speed adjustable over full range from 0 rpm to maximum scheduled speed.
 - 5. Variable motor speed to be controlled by a 0- to 10 V-dc or 4- to 20-mA input.
 - 6. Integrated motor protection verified by UL to protect the pump against over-/undervoltage, overtemperature of motor and/or electronics, overcurrent, locked rotor, and dry run (no-load condition).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

- A. Comply with [HI 1.4][and][HI 2.4].
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers,

couplings, and accessories.

- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.
- E. Equipment Mounting:
 - 1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- F. Equipment Mounting for In-Line Pumps Suspended from Structure: Install in-line pumps with continuous-thread hanger rods and **[elastomeric hangers][spring hangers][spring hangers with vertical-limit stop]** of size required to support weight of in-line pumps.
 - 1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 ALIGNMENT

- A. Engage a factory-authorized service representative to perform alignment service.
- B. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.
- C. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- D. Comply with pump and coupling manufacturers' written instructions.
- E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to pump, allow space for service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.



- E. Install **[check, shutoff, and throttling valves]****[check valve and throttling valve with memory stop]****[triple-duty valve]** on discharge side of pumps.
- F. Install **[Y-type strainer]****[suction diffuser]** and shutoff valve on suction side of pumps.
 - 1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.
- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- H. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.
- I. Install check valve on each condensate pump unit discharge unless unit has a factory-installed check valve.

3.5 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform]****[Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping. Use startup strainer for initial startup.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.

- b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
- c. Verify that pump is rotating in correct direction.
- 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
- 6. Start motor.
- 7. Open discharge valve slowly.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Hydronic pumps will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 23 21 23 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 21 23 00	23 21 00 00	Underground Hydronic Piping
23 21 23 13	23 21 00 00	Underground Hydronic Piping
23 21 23 13	23 21 23 00	Hydronic Pumps
23 21 23 16	23 21 00 00	Underground Hydronic Piping
23 21 23 16	23 21 23 00	Hydronic Pumps



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 21 23 23 - ELECTRIC-DRIVE, VERTICAL-TURBINE FIRE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire pumps - electric drive.
2. Fire-pump controllers - electric drive.
3. Fire-pump accessories and specialties.
4. Fire-pump controller remote alarm panels.
5. Grout.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on Project.
3. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" specifies seismic restraint and vibration isolation of fire-suppression equipment and piping.
4. Section 260010 "Supplemental Requirements for Electrical" specifies requirements applicable to coordinating, scheduling, and sequencing of the electrical Work specified in this Section.
5. Section 260573 "Power System Studies" specifies arc flash hazard analyses and arc flash hazard labeling.
6. Section 284600 "Fire Detection and Alarm" specifies supervisory connections to fire-alarm systems.

1.2 DEFINITIONS

- A. ECM: Electronic control module.
- B. MCCB: Molded-case circuit breaker.
- C. NPT: Normal pressure and temperature.
- D. PID: Proportional integral derivative.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for fire pump and fire-pump controller.
2. Include rated capacities, operating characteristics, factory-certified performance test curves, electrical characteristics, and furnished accessories and specialties.

B. Shop Drawings: For packaged fire-pump and electric-drive, fire-pump controller and fire-pump

accessories and specialties.

1. Provide fabrication and installation details, including plans, elevations, sections, and mounting and attachment details.
2. Provide details of equipment assemblies. Indicate dimensions; shipping, installed, and operating weights; loads; required clearances; method of field assembly; components; electrical characteristics; and location and size of each field connection.
3. Provide wiring diagrams for power, signal, and control wiring.
4. For fire-pump controllers, show the following:
 - a. Each installed unit's type and details.
 - b. Enclosure types and details for types other than NEMA 250, Type 2.
 - c. Factory-installed devices.
 - d. Nameplate legends.
 - e. Short-circuit current rating of integrated unit.
 - f. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.
 - g. Specified modifications.

C. Delegated Design Submittals: For fire pump and fire-pump controller.

1. Include design calculations for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fire pumps, controllers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of fire pump and fire-pump controller, from manufacturer.

C. Source quality control reports.

D. Field-acceptance testing and inspection reports for fire-pump controllers.

E. Field quality control reports.

F. Certified shop test curves showing head capacity and brake horsepower for each pump.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire pumps and fire-pump controllers to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match fire-pump controllers installed and that are packaged with protective coverings for storage and identified with labels describing contents.
1. Auxiliary Contacts: **[One]<Insert number>** for each size and type of magnetic contactor installed.
 2. Power Contacts: **[Three]<Insert number>** for each size and type of magnetic contactor installed.
 3. Contactor Coils: **[One]<Insert number>** for each size and type of magnetic controller installed.
 4. Relay Boards: **[One]<Insert number>** for each size and type of relay board installed.
 5. Operator Interface: **[One]<Insert number>** microprocessor board(s), complete with display and membrane keypad.
 6. **<Insert extra materials>**.

1.7 WARRANTY

- A. Manufacturer Warranty: **[Manufacturer agrees][Installer agrees][Manufacturer and Installer agree]** to repair or replace fire pumps and controllers that fail in materials or workmanship within specified warranty period.
- B. Special Warranty: **[Manufacturer agrees][Installer agrees][Manufacturer and Installer agree]** to repair or replace components of fire pumps and controllers, including **[auxiliary contacts for magnetic contactors][power contacts for magnetic contactors][contactor coils for magnetic contactors][relay boards][operator interface microprocessor boards]<Insert components>** that fail in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Fire pumps are to withstand the effects of earthquake motions determined in accordance with NFPA 20 **[and][ASCE/SEI 7][NFPA 13][NFPA 14]<Insert standard>**. See Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"
 2. Component Importance Factor: 1.5.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2.2 FIRE PUMPS - ELECTRIC DRIVE

- A. Fire Pump - Electric Drive, Vertical Turbine:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [A C Fire Pump; a Xylem brand]
 - b. [Patterson Pump Company; a Gorman-Rupp company]
 - c. [Peerless Pump Company]
 - d. [Pentair Aurora; Pentair Pump Group]
 - e. [Reddy-Buffaloes Pump Company]
 - f. [Ruhrpumpen, Inc]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [A C Fire Pump; a Xylem brand]
 - b. [Patterson Pump Company; a Gorman-Rupp company]
 - c. [Peerless Pump Company]
 - d. [Pentair Aurora; Pentair Pump Group]
 - e. [Reddy-Buffaloes Pump Company]
 - f. [Ruhrpumpen, Inc]
 - g. <Insert manufacturer's name>
3. Source Limitations:
- a. Obtain fire pump and electric drive from a single manufacturer.
 - b. Equipment provider is to provide services of a factory-authorized service representative and have a service facility located within a **60-mile (100-km)** radius of Project site.
4. Description: Factory-assembled and -tested fire pump and electric drive.
- a. Pump Equipment, Accessory, and Specialty Pressure Rating: [175 psig (1200 kPa)]<Insert minimum pressure> minimum.
 - b. Finish: Red paint applied to factory-assembled and -tested unit before shipping.
5. Standards:
- a. Comply with NFPA 20.
 - b. <Insert standard>.
6. Base: Fabricated and attached to fire-pump and driver unit, with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.
7. Pump Head: Cast iron, for surface discharge.
- a. Discharge Outlet: Flanged with flanges complying with ASME B16.1; except connections may be threaded in accordance with ASME B1.20.1, in sizes where flanges are not available.
 - b. Pump Head Seal: Stuffing box and packing.
 - c. Base: Cast iron or steel with hole for electrical cable.
8. Pump:
- a. Standard: [UL 448]<Insert standard>, for vertical-turbine pumps for fire service.
 - b. Discharge Head: High profile, with flange above ground outlet Class 125 for cast iron, and with flange above ground outlet Class 150 for steel, with **0.5-inch (12.7-mm)** NPT pressure

- gauge connection.
 - c. Stuffing Box: Cast iron with packing rings, pressure-relief connection, stainless steel packing gland, bronze bearing, and rubber slinger.
 - d. Line Shaft: Stainless steel in sections **10 ft. (3 m)** or less, with left-hand threaded steel couplings, centering spiders, and fluted rubber bearings.
 - e. Line Shaft Bearings: Bronze, water lubricated.
 - f. Bowl Section: Multiple close-grained, flanged cast-iron bowls.
 - g. Impeller: Closed type, **[silicon bronze][stainless steel]**, dynamically balanced, and securely fastened to the bowl.
 - h. Suction Bell: Close-grained cast-iron bowl with bronze bearing and bronze sand collar.
 - i. Wear Rings: Bronze located in the suction and intermediate bowls and with minimum clearance to the surface of the impeller.
 - j. Column Pipe: ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded sleeve couplings or rabbet fit flange ends in sections of **10 ft. (3 m)** or less.
 - k. Suction Strainer: Cast or fabricated; bronze, stainless steel, or Monel; and sized to restrict passage of **0.5-inch (12.7-mm)** diameter objects.
9. Driver:
- a. Type: Electric motor; NEMA MG 1, **[polyphase Design B][inverter-duty, for variable-speed controller]**.
 - b. Standard: **[UL 1004-1][UL 1004-5]<Insert standard>**.
 - c. Mounting: On pump head above pump.
10. Controller Type: **[Full service][Variable speed]**.
11. Capacities and Characteristics:
- a. Rated Capacity: **<Insert gpm (L/minute)>**.
 - b. Total Rated Head: **<Insert feet or psig (kPa)>**.
 - c. Inlet Column Size: **<Insert NPS (DN)>**.
 - d. Pump Column Length: **<Insert feet (m)>**.
 - e. Pump Head Outlet Flange: **[Class 125][Class 250]<Insert class>**.
 - f. Suction Head Available at Pump: **<Insert feet (m)>**.
 - g. Motor Horsepower: **<Insert number>** hp.
 - h. Motor Speed: **<Insert number>** rpm.
 - i. Electrical Characteristics:
 - 1) Volts: **[208][230][460]<Insert number>** V.
 - 2) Phase: Three.
 - 3) Hertz: 60.
 - 4) Full-Load Amperes: **<Insert number>** A.
 - 5) Minimum Circuit Ampacity: **<Insert number>** A.
 - 6) Maximum Overcurrent Protection: **<Insert number>** A.
12. Pump-Start, Pressure-Switch Setting: **<Insert psig (kPa)>**.
13. Pump-Stop, Pressure-Switch Setting: **<Insert psig (kPa)>**.
14. Source Quality Control:
- a. Manufacturer Testing: Test and inspect fire pumps in accordance with UL 448 requirements for operation test and manufacturing and production tests.
 - 1) Verification of Performance: Rate fire pumps in accordance with UL 448.
 - b. Prepare test and inspection reports.

2.3 FIRE-PUMP CONTROLLERS - ELECTRIC DRIVE

A. Fire-Pump Controller - Electric Drive, Full Service:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Eaton]**
 - b. **[Firetrol]**
 - c. **[Master Control Systems, Inc]**
 - d. **[Metron Eledyne; a Hubbell Company]**
 - e. **[Tornatech]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Firetrol]**
 - c. **[Master Control Systems, Inc]**
 - d. **[Metron Eledyne; a Hubbell Company]**
 - e. **[Tornatech]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations:
 - a. Obtain full-service controllers from single manufacturer.
 - b. Equipment provider is to provide services of a factory-authorized service representative and have a service facility located within a **60-mile (100 km)** radius of Project site.
4. Description:
 - a. Factory fabricated, assembled, wired, and tested; continuous-duty rated electric-drive full-service fire-pump controller.
 - b. Operation: **[Combined automatic and nonautomatic][Nonautomatic]** operation.
 - c. Listed as arc resistant.
 - d. Provided with arc flash mitigation.
5. Standards:
 - a. Comply with NFPA 20, including the personnel protection requirements for arc flash mitigation
 - b. Comply with NFPA 70E.
 - c. Comply with NFPA 72.
 - d. **<Insert standard>**.
 - e. **<Insert approval>**.
 - f. IEEE Compliance: Fabricate and test enclosed controllers in accordance with IEEE 344 to withstand seismic forces defined in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria."
6. Listing Criteria: Investigated, labeled, and marked by UL Solutions, Inc., in accordance with guide

information and standards specified for the following product categories:

- a. Fire-Pump Controllers: UL CCN QYZS, including UL 508 and UL 218.
 - b. Fire-Pump Controllers Over 600 V: UL CCN QYZS, including UL 218, and UL 347.
 - c. Fire-Pump Controllers for use in Hazardous Locations: UL CCN RCYW, including UL 508 and UL 218.
7. Method of Starting:
- a. Actuation: **[Pressure][Nonpressure]**-switch actuated.
 - 1) Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
 - 2) Programmable minimum-run-time relay to prevent short cycling.
 - 3) Programmable timer for weekly tests.
 - b. Full-Voltage Starting: **[Across-the-line][Autotransformer][Part-winding][Primary-resistor][Primary-reactor][Wye-delta (open transition)][Wye-delta (closed transition)]<Insert type>** type magnetic controller.
 - c. Reduced-Voltage Starting: **[Reduced-voltage]<Insert type>** type solid-state controller.
 - d. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of electric or pressure actuators.
8. Method of Stopping: **[Automatic and nonautomatic shutdown after automatic starting][Nonautomatic]**.
9. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current rating equal to or greater than short-circuit current available at controller location.
10. Alternate-Source Isolating and Disconnecting Means:
- a. Integral molded-case switch, with an externally mounted operating handle.
 - b. Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker must be provided with nonthermal sensing, instantaneous-only short-circuit overcurrent protection to comply with available fault currents.
11. Enclosure:
- a. NEMA 250, **[Type 2][Type 3R][Type 4][Type 4X][Type 12]<Insert type>**, IP31 **<Insert type>** minimum.
 - b. Comply with environmental conditions at installed location and NFPA 20.
 - c. Enclosure Color: **[Manufacturer's standard "fire-pump-controller red"]<Insert color>**.
 - d. Overcurrent protection device must be located in a separate enclosure or separate compartment attached to the fire-pump controller.
 - e. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.
 - f. Arc Flash Mitigation for Personnel Protection:
 - 1) Locate controller isolating switch, with instantaneous-only overcurrent protection, in a separate enclosure or compartment attached to the controller.
 - 2) Construction of the separate enclosure or compartment must be able to totally isolate incoming normal power from the main enclosure and must be marked to prohibit energized work.
 - 3) Controllers must be listed as arc resistant.
 - g. Features:



- 1) Floor stands, **12 inches (305 mm)** high, for floor-mounted controllers.
- 2) Space heater, [**120 V ac**][**240 V ac**], **with humidistat**[], **with thermostat**].
- 3) Tropicalization.
- 4) **<Insert feature>**.

12. Door-Mounted Operator Interface and Controls:

- a. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
 - 1) Pressure and event recorder capable of logging pressure data and operational events with time and date stamp for the life of the controller. Data is to be retrievable and downloadable to a flash memory drive via a USB port accessible to the user without having to open the controller door.
- b. Touch Screen Operator Interface:
 - 1) Provide minimum **7-inch (178-mm)** LCD color touch screen powered by an embedded microprocessor with software.
 - 2) In addition to push-button operation for START/STOP/RUN TEST and graphic display of system operations, the control is to allow programming of cut-in and cut-out pressures and minimum runtime and is also to allow for onscreen viewing of corresponding Owner's Manual in chosen language.
- c. Local and Remote Alarm and Status Indications:
 - 1) Local alarms are to visually indicate and differentiate by color the following:
 - a) Locked rotor current.
 - b) Fail to start.
 - c) Undercurrent.
 - d) Overcurrent.
 - e) Undervoltage.
 - f) Overvoltage.
 - g) Phase unbalance.
 - h) Weekly test solenoid valve.
 - i) Weekly test cut-in not reached.
 - j) Transducer fault.
 - k) Control voltage not healthy.
 - l) Motor trouble.
 - m) Pump room alarm.
 - n) Invalid cut-in.
 - o) Phase reversal.
 - p) Power loss.
 - q) Phase loss L1.
 - r) Phase loss L2.
 - s) Phase loss L3.
 - t) Low water level.
 - u) Pump on demand.
 - v) Low ambient temperature.
 - w) Service required.
 - 2) Remote Alarms: Provide double pole/double throw dry contact relays for remote alarms for the following:

- a) Power or phase failure and/or circuit breaker in open position.
 - b) Phase reversal.
 - c) Pump run.
 - d) Common pump room alarm (field re-assignable).
 - e) Field programmable.
 - d. Audible alarm with PUSH TO SILENCE button.
 - e. Nonautomatic START and STOP push buttons or switches.
 - f. **<Insert function>**.
13. Features:
- a. Extra Output Contacts:
 - 1) **[One]<Insert number>** NO contact(s) for motor running condition.
 - 2) **[One]<Insert number>** set(s) of contacts for loss-of-line power.
 - 3) **[One]<Insert number>** each, Form C contacts for high and low reservoir level.
 - 4) **<Insert contact type>**.
 - b. Operator Interface Communications Ports: USB, Ethernet, and complying with ANSI/TIA/EIA-485-A.
 - c. Communications Protocol Capability: Modbus with TCP/IP frame format and shielded female RJ45 connector.
 - d. **<Insert optional feature>**.
14. Automatic Transfer Switch:
- a. Complies with NFPA 20 **[UL 218][and][UL 1008]<Insert standard(s)>**.
 - b. Integral to controller as a listed combination fire-pump controller and power transfer switch.
 - c. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
 - d. Allows manual transfer from one source to the other.
 - e. Alternate-Source Isolating and Disconnecting Means:
 - 1) Integral molded-case switch, with an externally mounted operating handle.
 - 2) Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker must be provided with nonthermal sensing, instantaneous-only, short-circuit overcurrent protection to comply with available fault currents.
 - f. Local and Remote Alarm and Status Indications:
 - 1) Normal source available.
 - 2) Alternate source available.
 - 3) In normal position.
 - 4) In alternate position.
 - 5) Isolating means open.
 - 6) **<Insert indication>**.
 - g. Audible alarm with PUSH TO SILENCE button.
 - h. Nonautomatic (manual, nonelectric) means of transfer.
 - i. Engine test push button.
 - j. Start generator output contacts.
 - k. Timer for weekly generator tests.
 - l. **<Insert function>**.



15. Source Quality Control:

- a. Manufacturer Testing: Test and inspect fire-pump controllers in accordance with requirements in NFPA 20 **[and][UL 218]<Insert standard>**.
- 1) Verification of Performance: Rate controllers in accordance with operation of functions and features specified.
- b. Prepare test and inspection reports.

B. Fire-Pump Controller - Electric Drive, Variable Speed:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Firetrol]**
 - b. **[Master Control Systems, Inc]**
 - c. **[Tornatech]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Firetrol]**
 - b. **[Master Control Systems, Inc]**
 - c. **[Tornatech]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitations:
 - a. Obtain variable-speed controllers from single manufacturer.
 - b. Equipment provider is to provide services of a factory-authorized service representative and have a service facility located within a **60-mile (100 km)** radius of the Project site.
- 4. Description:
 - a. Factory fabricated, assembled, wired, and tested; continuous-duty rated electric-drive variable-speed fire-pump controller.
 - b. Operation: **[Combined automatic and nonautomatic][Nonautomatic]** operation.
- 5. Standards:
 - a. Comply with NFPA 20, including the personnel protection requirements for arc flash mitigation.
 - b. Comply with NFPA 70E.
 - c. Comply with NFPA 72.
 - d. **<Insert standard>**.
 - e. **<Insert approval>**.
 - f. IEEE Compliance: Fabricate and test enclosed controllers in accordance with IEEE 344 to withstand seismic forces defined in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria."

6. Listing Criteria: Investigated, labeled, and marked by UL Solutions, Inc., in accordance with guide information and standards specified for the following product categories:
 - a. Fire-Pump Controllers: UL CCN QYZS, including UL 508 and UL 218.
 - b. Fire-Pump Controllers Over 600 V: UL CCN QYZS, including UL 218, and UL 347.
 - c. Fire-Pump Controllers for Use in Hazardous Locations: UL CCN RCYW, including UL 508 and UL 218.
7. Method of Starting:
 - a. Actuation: **[Pressure][Nonpressure]**-switch actuated.
 - 1) Water-pressure-actuated switch and pressure transducer with independent high-and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
 - 2) Programmable minimum-run-time relay to prevent short cycling.
 - 3) Programmable timer for weekly tests.
8. Variable-Speed Controller:
 - a. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
 - b. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
 - c. Enclosure: Unit mounted, NEMA 250, **[Type 1][Type 12]<Insert type>**, with hinged full-front access door with lock and key.
 - d. Externally Operated Disconnect: **[Door-interlocked disconnect switch][Fused disconnect switch][Nonfused disconnect switch][Circuit breaker]** with lockable handle.
 - e. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000][65,000][100,000]<Insert value> A**.
 - f. Technology: Pulse-width-modulation (PWM) output with insulated gate bipolar transistors (IGBTs); suitable for variable torque loads.
 - g. Controller is to consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
 - h. Output Rating: Three phase, with voltage proportional to frequency throughout voltage range.
 - i. Output signal is to be programmed to not cause mechanical vibration issues with pump drive assembly.
 - j. Operating Requirements:
 - 1) Input AC Voltage Tolerance: **[10]<Insert number>** percent.
 - 2) Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - 3) Capable of driving full motor load, without derating.
 - 4) Minimum Efficiency: **[96]<Insert value>** percent at 60 Hz, full load.
 - 5) Minimum Displacement Primary-Side Power Factor: **[95]<Insert value>** percent.
 - 6) Overload Capability: **[1.05]<Insert value>** times the full-load current for 7 seconds.
 - 7) Starting Torque: As required by pump and motor drive assembly.
 - 8) Speed Regulation: **[1]<Insert value>** percent.
 - 9) Speed Range: **[10:1]<Insert range>** speed range.
 - 10) To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller will not operate continuously.
 - 11) Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
 - k. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.

- I. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions is not to result in component failure or need for replacement:
 - 1) Surge suppression.
 - 2) Loss of input signal protection.
 - 3) Critical frequency rejection.
 - 4) Overtemperature.
 - 5) Short circuit at controller output.
 - 6) Ground fault at controller output. Variable-frequency controller is to be able to start a grounded motor.
 - 7) Open circuit at controller output.
 - 8) Input undervoltage.
 - 9) Input overvoltage.
 - 10) Loss of input phase.
 - 11) Reverse phase.
 - 12) AC line switching transients.
 - 13) Instantaneous overload, line to line, or line to ground.
 - 14) Sustained overload exceeding 100 percent of controller rated current.
 - 15) Starting a rotating motor.
 - 16) **<Insert features>**.
- m. Motor Protection: Controller is to protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
- n. Automatic Reset and Restart:
 - 1) Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
 - 2) Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
- o. Visual Indication: On face of controller, indicating the following conditions:
 - 1) Power on.
 - 2) Run.
 - 3) Overcurrent and overvoltage.
 - 4) Motor speed (percentage).
 - 5) Various faults with alarm status.
 - 6) Input kilovolt amperes.
 - 7) Power factor.
 - 8) Input kilowatts and kilowatt-hours.
 - 9) Three-phase input and output voltage.
 - 10) Three-phase input and output current.
 - 11) Output frequency.
 - 12) Elapsed operating time (hours).
 - 13) Diagnostic and service parameters.
 - 14) **<Insert conditions>**.
- p. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
- q. Hardwired Control Signal Interface: A minimum of [two]**<Insert number>** analog inputs (0 to 10 V or 0/4 to 20 mA) and [four]**<Insert number>** programmable digital inputs.
- r. Remote Communication Interface: [ASHRAE 135 BACnet MS/TP][ASHRAE 135 BACnet IP]**<Insert requirements>**.
- s. Line Conditioning:
 - 1) Input line conditioning.

- 2) Output filtering.
- 3) EMI/RFI filtering.
- t. Bypass Controller:
 - 1) Bypass Controller/Variable-Frequency Controller Selector Switch: Include manual selector switch on face of enclosure for local operator control of preferred controller.
 - 2) Bypass Mode: [**Field-selectable automatic**]**<Insert mode>**.
 - a) In automatic mode, include fail-safe control logic to automatically transfer pump motor operation from failed variable-frequency controller to bypass controller.
 - 3) Type: Integrated NEMA ICS 2, Class A, full-voltage, nonreversing, motor-rated controller to operate pump motor if variable-frequency controller is not operational.
 - 4) Arrangement: Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating pump motor through bypass controller for safe servicing of variable-frequency controller.
 - 5) Enclosure: Install bypass controller in same enclosure as variable-frequency controller.
 - 6) Remote Monitoring: Include control relay for remote indication of bypass controller operation.
9. Method of Stopping: [**Automatic and nonautomatic shutdown after automatic starting**]**[Nonautomatic]**.
10. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current rating equal to or greater than short-circuit current available at controller location.
11. Alternate-Source Isolating and Disconnecting Means:
 - a. Integral molded-case switch, with an externally mounted operating handle.
 - b. Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker must be provided with nonthermal sensing, instantaneous-only, short-circuit overcurrent protection to comply with available fault currents.
12. Enclosure:
 - a. NEMA 250, [**Type 2**]**[Type 3R]****[Type 4]****[Type 4X]****[Type 12]****<Insert type>**, IP31 **<Insert type>** minimum.
 - b. Comply with environmental conditions at installed location and NFPA 20.
 - c. Enclosure Color: [**Manufacturer's standard "fire-pump-controller red"**]**<Insert color>**.
 - d. Overcurrent protection device must be located in a separate enclosure or separate compartment attached to the fire-pump controller.
 - e. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.
 - f. Arc Flash Mitigation for Personnel Protection:
 - 1) Locate controller isolating switch, with instantaneous-only overcurrent protection, in a separate enclosure or compartment attached to the controller.
 - 2) Construction of the separate enclosure or compartment must be able to totally isolate incoming normal power from the main enclosure and must be marked to prohibit energized work.
 - 3) Controllers must be listed as arc resistant.
 - g. Features:

- 1) Floor stands, **12 inches (305 mm)** high, for floor-mounted controllers.
- 2) Space heater, [**120 V ac**][**240 V ac**][, with humidistat][, with thermostat].
- 3) Tropicalization.
- 4) **<Insert optional feature>**.

13. Door-Mounted Operator Interface and Controls:

- a. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
 - 1) Pressure and event recorder capable of logging pressure data and operational events with time and date stamp for the life of the controller. Data is to be retrievable and downloadable to a flash memory drive via a USB port accessible to the user without having to open the controller door.
- b. Touch Screen Operator Interface:
 - 1) Provide minimum **7-inch (178-mm)** LCD color touch screen powered by an embedded microprocessor with software.
 - 2) In addition to push button operation for START/STOP/RUN TEST and graphic display of system operations, the control is to allow programming of cut-in and cut-out pressures and minimum runtime and is also to allow for onscreen viewing of corresponding Owner's Manual in chosen language.
- c. Local and Remote Alarm and Status Indications:
 - 1) Local alarms are to visually indicate and differentiate by color the following:
 - a) Controller power on.
 - b) Motor running condition.
 - c) Loss-of-line power.
 - d) Line-power phase reversal.
 - e) Line-power single-phase condition.
 - 2) Remote Alarms: Provide double pole/double throw dry contact relays for remote alarms for the following:
 - a) Power or phase failure and/or circuit breaker in open position.
 - b) Phase reversal.
 - c) Pump run.
 - d) Common pump room alarm (field re-assignable).
 - e) Field programmable **<Insert remote alarm>**.
- d. Audible alarm with PUSH TO SILENCE button.
- e. Nonautomatic START and STOP push buttons or switches.
- f. Set pressure and system pressure.
- g. **<Insert function>**.

14. Features:

- a. Extra Output Contacts:
 - 1) [**One**]**<Insert number>** NO contact(s) for motor running condition.
 - 2) [**One**]**<Insert number>** set(s) of contacts for loss-of-line power.
 - 3) [**One**]**<Insert number>** each, Form C contacts for high and low reservoir level.

- 4) **<Insert contact type>.**
 - b. Operator Interface Communications Ports: USB, Ethernet, and complying with ANSI/TIA/EIA-485-A.
 - c. Communications Protocol Capability: Modbus with TCP/IP frame format and shielded female RJ45 connector.
 - d. **<Insert optional feature>.**
15. Automatic Transfer Switch:
- a. Complies with NFPA 20 [UL 218][and][UL 1008]**<Insert standard>.**
 - b. Integral with controller as a listed combination fire-pump controller and power transfer switch.
 - c. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
 - d. Allows manual transfer from one source to the other.
 - e. Alternate-Source Isolating and Disconnecting Means:
 - 1) Integral molded-case switch, with an externally mounted operating handle.
 - 2) Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker must be provided with nonthermal sensing, instantaneous-only, short-circuit overcurrent protection to comply with available fault currents.
 - f. Local and Remote Alarm and Status Indications:
 - 1) Normal source available.
 - 2) Alternate source available.
 - 3) In normal position.
 - 4) In alternate position.
 - 5) Isolating means open.
 - 6) **<Insert indication>.**
 - g. Audible alarm with PUSH TO SILENCE button.
 - h. Nonautomatic (manual, nonelectric) means of transfer.
 - i. Engine test push button.
 - j. Start generator output contacts.
 - k. Timer for weekly generator tests.
 - l. **<Insert function>.**
16. Variable-Speed Drive Operational Modes:
- a. Operated in a PID process control loop to control the centrifugal fire-pump speed to limit the system pressure.
 - b. PID controller receives signal from the pressure transducer that measures the system pressure.
 - c. PID output controls the current frequency of the pump motor regulating the pump speed to maintain the system pressure at the set point.
 - d. Upon detection of a drive failure, the drive is bypassed and the motor runs at full speed.
 - e. Once set-point pressure is maintained for a set period, the drive soft stops the pump motor.
 - f. Provides both soft start and soft stop of the pump motor.
17. Source Quality Control:
- a. Manufacturer Testing: Test and inspect fire-pump controllers in accordance with requirements in NFPA 20 [and][UL 218]**<Insert standard>.**

- 1) Verification of Performance: Rate controllers in accordance with operation of functions and features specified.

- b. Prepare test and inspection reports.

2.4 FIRE-PUMP ACCESSORIES AND SPECIALTIES

- A. Automatic Air-Release Valve: Comply with NFPA 20 for installation in fire-pump discharge piping.
- B. Circulation Relief Valve: UL 1478, brass, spring loaded; for installation in pump discharge piping.
- C. Outlet Fitting: Concentric tapered reducer at pump-head discharge outlet.
- D. Discharge Cone: **[Closed][Open][Closed or open]** type.
- E. Fire-Pump Relief Valve:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[BERMAD Control Valves]**
 - b. **[CLA-VAL]**
 - c. **[Kunkle Valve]**
 - d. **[OCV Control Valves]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[BERMAD Control Valves]**
 - b. **[CLA-VAL]**
 - c. **[Kunkle Valve]**
 - d. **[OCV Control Valves]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**
 3. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
- F. Fire-Pump Test Connection:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Fire Supply]**

- b. **[CLA-VAL]**
 - c. **[Croker; a Division of Morris Group International]**
 - d. **[Guardian Fire Equipment, Inc]**
 - e. **[Potter Roemer LLC; a Division of Morris Group International]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Fire Supply]**
 - b. **[CLA-VAL]**
 - c. **[Croker; a Division of Morris Group International]**
 - d. **[Guardian Fire Equipment, Inc]**
 - e. **[Potter Roemer LLC; a Division of Morris Group International]**
 - f. **<Insert manufacturer's name>**
 3. Standards:
 - a. NFPA 20.
 - b. UL 405, except outlets without clappers instead of inlets.
 4. Description: **[Flush, for wall mounting][Freestanding]<Insert type>**.
 5. Pressure Rating: **175 psig (1200 kPa)** minimum.
 6. Body Material: Corrosion-resistant metal with number of outlets required by NFPA 20.
 7. Escutcheon Plate: Brass or bronze.
 8. Hose Valves: UL 668, bronze, with outlet threaded in accordance with NFPA 1963 and matching local fire-department threads. Include caps and chains.
 9. Exposed Parts Finish: **[Polished][Rough][brass][, chrome plated]**.
 10. Escutcheon Plate Marking: **[FIRE-PUMP TEST CONNECTION]<Insert marking>**.
- G. Fire-Pump Flowmeter Systems:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Fire Research Corp]**
 - b. **[Gerand Engineering Co]**
 - c. **[Hyspan Precision Products, Inc]**
 - d. **[Victaulic Company]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Fire Research Corp]**
 - b. **[Gerand Engineering Co]**
 - c. **[Hyspan Precision Products, Inc]**
 - d. **[Victaulic Company]**
 - e. **<Insert manufacturer's name>**
 3. Description: UL-listed or FM-Approved, fire-pump flowmeter system able to indicate flow to not less than 175 percent of fire-pump rated capacity.

4. Pressure Rating: **[175 psig (1200 kPa) minimum][250 psig (1725 kPa)][300 psig (2070 kPa)]<Insert pressure>**.
5. Sensor: **[Venturi][Paddlewheel]<Insert type>**. Sensor size is to match pipe, tubing, flowmeter, and fittings.
6. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than **4-1/2 inches (115 mm)** in diameter. **[Include bracket or device for wall mounting.]**
 - a. Tubing Package: **NPS 1/8 or NPS 1/4 (DN 6 or DN 10)** plastic tubing with copper or brass fittings and valves.
7. Portable Flowmeter: Compatible with flow sensor, with dial not less than **4-1/2 inches (115 mm)** in diameter and with two **12-foot- (3.7-m-)** long hoses in carrying case.

2.5 FIRE-PUMP CONTROLLER REMOTE ALARM PANELS**A. Fire-Pump Controller Remote Alarm Panel:**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eaton]**
 - b. **[Firetrol]**
 - c. **[Master Control Systems, Inc]**
 - d. **[Metron Eledyne; a Hubbell Company]**
 - e. **[Tornatech]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Firetrol]**
 - c. **[Master Control Systems, Inc]**
 - d. **[Metron Eledyne; a Hubbell Company]**
 - e. **[Tornatech]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain remote alarm panels from single manufacturer.
4. Standards:
 - a. Comply with NFPA 20.
 - b. **<Insert standard>**.
5. Description:
 - a. Factory fabricated, assembled, wired, and tested.
6. Supervisory and Normal Control Voltage: **[120 V ac][208 V ac]<Insert voltage>; [single][dual]** source.
7. Audible and Visual Alarm and Status Indications for Electric-Driven Pump Controllers:

- a. Driver running.
 - b. Loss of phase.
 - c. Phase reversal.
 - d. Supervised power on.
 - e. Trouble Alarm: **[Common][Separate]** trouble on the controller.
 - 1) **<Insert alarm>**.
 - f. Controller connected to alternate power source.
 - g. **<Insert indication>**.
- 8. Audible alarm, with SILENCE push button.
 - 9. Pump REMOTE START push button.

2.6 GROUT

- A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink and recommended for interior and exterior applications.
- C. Design Mix: **5000 psi (34 MPa)**, 28-day compressive strength.
 - 1. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surface to receive equipment, equipment bases, and anchorage provisions, with installing contractor(s), **[Architect][Engineer][Construction Manager][and]** Manufacturer's Representative present, for compliance with requirements for installation tolerances and other conditions affecting performance of the fire pump and fire-pump controller.
- B. Examine roughing-in for fire-suppression piping systems to verify actual locations of piping connections before fire-pump installation.
- C. Examine equipment before installation. Reject equipment that is wet or damaged by moisture or mold.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PROTECTION OF FIRE-PUMP CONTROLLERS

- A. Temporary Heating: Apply temporary heat to maintain temperature in accordance with manufacturer's written instructions until enclosed fire-pump controllers are ready to be energized and placed into service.
- B. Replace fire-pump controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.3 INSTALLATION OF FIRE PUMPS

- A. Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
- B. Equipment Mounting:
 - 1. Install fire pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria."
 - 3. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."
- C. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.
- D. Support piping and pumps separately, so weight of piping does not rest on pumps.
- E. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Section 211000 "Water-Based Fire-Suppression Systems."
- F. Install pressure gauges on fire-pump suction and pump-head discharge flange pressure-gauge tapings. Comply with requirements for pressure gauges specified in Section 211000 "Water-Based Fire-Suppression Systems."
- G. Install piping hangers and supports, anchors, valves, gauges, and equipment supports in accordance with NFPA 20 **[NFPA 13][and][NFPA 14]<Insert standard>**.
- H. Install flowmeters and sensors. Install flowmeter-system components and make connections in accordance with NFPA 20 and manufacturer's written instructions.
- I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

3.4 ALIGNMENT OF FIRE PUMPS

- A. Align fire-pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
- B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
- C. Align piping connection.
- D. Align pump and driver shafts for angular and parallel alignment in accordance with HI 2.4 and to tolerances specified by manufacturer.

3.5 PIPING CONNECTIONS

- A. Comply with requirements for piping and valves specified in Section 211000 "Water-Based Fire-Suppression Systems." Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Install piping adjacent to pumps and equipment to allow service and maintenance.
- C. Connect relief-valve discharge to drainage piping or point of discharge.
- D. Connect flowmeter-system meters, sensors, and valves to tubing.
- E. Connect fire pumps to their controllers.

3.6 INSTALLATION OF FIRE-PUMP CONTROLLERS

- A. Coordinate installation of controllers with other construction, including conduit, piping, fire-pump equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels. Ensure that controllers are within sight of fire-pump drivers.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.
- C. Install controllers within sight of their respective drivers.
- D. Connect controllers to their dedicated pressure-sensing lines.
- E. Wall-Mounting Controllers: Install controllers on walls with disconnect operating handles not higher than **79 inches (2 m)** above finished floor, and bottom of enclosure not less than **12 inches (305 mm)** above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."
- F. Floor-Mounting Controllers: Install controllers on concrete base(s), using floor stands high enough so that the bottom of enclosure cabinet is not less than **12 inches (305 mm)** above finished floor. Comply with requirements for concrete bases specified in Section 260529 "Hangers and Supports for Electrical Systems."
 - 1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - 2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 3. Install anchor bolts to elevations required for proper attachment to supported equipment.
- G. Seismic Bracing: Comply with requirements specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria."
- H. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- I. Comply with NEMA ICS 15.
- J. Installation of Power Wiring:
 - 1. Install power wiring between fire-pump controllers and their services or sources, and between fire-pump controllers and their drivers. Comply with requirements in NFPA 20, NFPA 70, and Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 2. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

K. Installation of Control and Alarm Wiring:

1. Install wiring between fire-pump controllers and remote devices[**and facility's central monitoring system**]. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."
2. Install wiring between remote alarm panels and fire-pump controllers. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."
3. Install wiring between controllers and the building's fire-alarm system. Comply with requirements specified in Section 284600 "Fire Detection and Alarm."
4. Bundle, train, and support wiring in enclosures.
5. Connect remote manual and automatic activation devices where applicable.

L. Field-Acceptance Testing and Inspection:

1. Acceptance Testing Preparation:
 - a. Inspect and Test Each Component:
 - 1) Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
 - 2) Test insulation resistance for each element, component, connecting supply, feeder, and control circuits.
 - 3) Test continuity of each circuit.
 - b. Verify and Test Each Electric-Drive Controller:
 - 1) Verify that voltages at controller locations are within plus 10 or minus 1 percent of motor nameplate rated voltages, with motors off. If outside this range for motor, notify **[Architect][Construction Manager][Owner]** before starting the motor(s).
 - 2) Test each motor for proper phase rotation.
 - 3) Verify short-circuit current rating.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Representatives from manufacturers of fire-pump controllers must be present during acceptance tests and inspections in accordance with NFPA 20.
3. Acceptance tests and inspections must be witnessed by **[Architect][Construction Manager][Owner][authorities having jurisdiction]<Insert names or titles of witnesses>**.
4. Acceptance Tests and Inspections:
 - a. Do not begin field-acceptance testing until suction piping has been flushed and hydrostatically tested and the certificate for flushing and testing has been submitted to **[Architect][Construction Manager][Owner]** and authorities having jurisdiction.
 - b. Prior to starting, notify authorities having jurisdiction of the time and place of the acceptance testing.
 - c. Engage manufacturer's factory-authorized service representative to be present during the testing.
 - d. Perform field-acceptance tests in accordance with NFPA 20.
5. Nonconforming Work:
 - a. Controllers will be considered defective if they do not pass tests and inspections.

- b. Remove and replace defective units with new units and retest.
- 6. Prepare and submit field testing and inspection reports.
- 3.7 INSTALLATION OF FIRE-PUMP CONTROLLER REMOTE ALARM PANELS
 - A. Install panels on walls with tops not higher than **[72 inches (1829 mm)]<Insert height>** above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For panels not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."
- 3.8 IDENTIFICATION OF FIRE PUMPS AND FIRE-PUMP CONTROLLERS
 - A. Comply with requirements in NFPA 20 for marking of fire pumps and fire-pump controllers.
 - B. Field label controllers for arc flash risk in accordance with NFPA 70E.
 - C. Permanently mark fire-pump controller enclosure and overcurrent protective device enclosure to prohibit energized work in accordance with NFPA requirements.
 - D. Identify equipment, system components, piping, wiring, cabling, and terminals. Comply with requirements for identification in NFPA 20 and as specified in Section 210553 "Identification for Fire-Suppression Piping and Equipment" and Section 260553 "Identification for Electrical Systems."
- 3.9 STARTUP SERVICE FOR FIRE PUMPS AND CONTROLLERS
 - A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. **<Insert startup steps>**.
- 3.10 ADJUSTING
 - A. Adjust fire-pump controllers[**and battery charger systems**] to function smoothly and as recommended by manufacturer.
 - B. Set field-adjustable switches, auxiliary relays, time-delay relays, and timers.
 - C. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
 - D. Set field-adjustable pressure switches.
- 3.11 FIELD QUALITY CONTROL
 - A. Test each fire pump with its controller as a unit.
 - B. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.



- C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- D. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**].
 - 1. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
 - 2. Test in accordance with NFPA 20 for acceptance and performance testing.
 - a. Prior to initial setup and acceptance testing, complete and check all electric wiring serving fire-pump motor, including control interwiring, normal power, alternate power, and pressure-maintenance pump.
 - b. Perform arc flash risk assessment for all electric fire-pump controllers in accordance with NFPA 70E or other code required by the authorities having jurisdiction.
 - c. Field label electric fire-pump controllers for arc flash risk in accordance with NFPA 70E or other code required by authorities having jurisdiction.
 - 3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.12 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain fire pump and associated controller.

END OF SECTION 23 21 23 23

SECTION 23 21 23 23A - DIESEL-DRIVE, VERTICAL-TURBINE FIRE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire pumps - diesel drive, vertical turbine
2. Diesel engine driver.
3. Fire-pump controllers - for diesel-drive fire pumps.
4. Fire-pump accessories and specialties.
5. Fuel oil storage.
6. Fire-pump controller remote alarm panel.
7. Grout.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on Project.
3. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" specifies seismic restraint and vibration isolation of fire suppression equipment and piping.
4. Section 260010 "Supplemental Requirements for Electrical" specifies requirements applicable to coordinating, scheduling, and sequencing of the electrical Work specified in this Section.
5. Section 284600 "Fire Detection and Alarm" specifies supervisory connections to fire-alarm systems.

1.2 DEFINITIONS

- A. ECM:** Electronic control module.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for fire pump and fire-pump controller.
2. Include rated capacities, operating characteristics, factory-certified performance test curves, electrical characteristics, and furnished accessories and specialties.

B. Shop Drawings: For packaged fire-pump, right-angle gear drive, and diesel-driver, fire-pump controller and fire-pump accessories and specialties.

1. Provide fabrication and installation details, including plans, elevations, sections, and mounting and attachment details.
2. Provide details of equipment assemblies. Indicate dimensions; shipping, installed, and operating weights; loads; required clearances; method of field assembly; components; electrical

- characteristics; and location and size of each field connection.
- 3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- 4. Provide wiring diagrams for power, signal, and control wiring.
- 5. For fire-pump controllers, show the following:
 - a. Each installed unit's type and details.
 - b. Enclosure types and details for types other than NEMA 250, Type 2.
 - c. Factory-installed devices.
 - d. Nameplate legends.
 - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.
 - f. Specified modifications.
- C. Delegated Design Submittals: For fire pump and fire-pump controller.
 - 1. Include design calculations for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Certificates: For each type of fire pump and fire-pump controller, from manufacturer.
- C. Source quality control reports.
- D. Field-acceptance testing and inspection reports for fire-pump controllers.
- E. Field quality control reports.
- F. Certified shop test curves showing head capacity and brake horsepower for each pump.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire pumps and fire-pump controllers to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match fire-pump controllers installed and that are packaged with protective coverings for storage and identified with labels describing contents.

1. Auxiliary Contacts: **[One]<Insert number>** for each size and type of magnetic contactor installed.
2. Power Contacts: **[Three]<Insert number>** for each size and type of magnetic contactor installed.
3. Contactor Coils: **[One]<Insert number>** for each size and type of magnetic controller installed.
4. Relay Boards: **[One]<Insert number>** for each size and type of relay board installed.
5. Operator Interface: **[One]<Insert number>** microprocessor board(s), complete with display and membrane keypad.
6. **<Insert extra materials>**.

1.7 WARRANTY

- A. Manufacturer Warranty: **[Manufacturer agrees][Installer agrees][Manufacturer and Installer agree]** to repair or replace fire pumps and controllers that fail in materials or workmanship within specified warranty period.
- B. Special Warranty: **[Manufacturer agrees][Installer agrees][Manufacturer and Installer agree]** to repair or replace components of fire pumps and controllers, including **[auxiliary contacts for magnetic contactors][power contacts for magnetic contactors][contactor coils for magnetic contactors][relay boards][operator interface microprocessor boards]<Insert components>** that fail in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Fire pumps are to withstand the effects of earthquake motions determined in accordance with NFPA 20 **[and][ASCE/SEI 7][NFPA 13][NFPA 14]**. See Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]."**
 2. Component Importance Factor: 1.5.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2.2 FIRE PUMPS - DIESEL DRIVE, VERTICAL TURBINE

- A. Fire Pumps - Diesel Drive, Vertical Turbine:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A C Fire Pump; a Xylem brand]**
 - b. **[Armstrong Fluid Technology]**
 - c. **[Patterson Pump Company; a Gorman-Rupp company]**

- d. [Peerless Pump Company]
 - e. [Pentair Aurora; Pentair Pump Group]
 - f. [Reddy-Buffaloes Pump Company]
 - g. [Ruhrpumpen, Inc]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [A C Fire Pump; a Xylem brand]
 - b. [Armstrong Fluid Technology]
 - c. [Patterson Pump Company; a Gorman-Rupp company]
 - d. [Peerless Pump Company]
 - e. [Pentair Aurora; Pentair Pump Group]
 - f. [Reddy-Buffaloes Pump Company]
 - g. [Ruhrpumpen, Inc]
 - h. <Insert manufacturer's name>
3. Source Limitations:
- a. Obtain fire pump, right-angle gear, and diesel drive from single manufacturer.
 - b. Equipment provider is to provide services of a factory-authorized service representative and have a service facility located within a **60-mile (100-km)** radius of Project site.
4. Description: Factory fabricated, assembled and tested fire pump, right-angle gear drive, and diesel drive.
- a. Pump Equipment, Accessory, and Specialty Pressure Rating: [175 psig (1200 kPa)]<Insert minimum pressure> minimum.
 - b. Finish: Red paint applied to factory-assembled and -tested unit before shipping.
5. Standards:
- a. Comply with NFPA 20.
 - b. <Insert standard>.
6. Base: Fabricated and attached to fire pump, right-angle gear drive, and driver, with reinforcement to resist movement of pump, gear drive, and driver during seismic events when base is anchored to building substrate.
7. Pump Head: Cast iron, for surface discharge.
- a. Discharge Outlet: With flange in accordance with ASME B16.1, except connections may be threaded in accordance with ASME B1.20.1, in sizes where flanges are not available.
 - b. Pump Head Seal: Stuffing box and packing.
 - c. Base: Cast iron or steel with hole for electrical cable.
8. Pump:
- a. Standard: [UL 448]<Insert standard>, for vertical-turbine pumps for fire service.
 - b. Discharge Head: High-profile cast iron or steel, with flanged, aboveground, outlet Class 125 for cast iron and Class 150 for steel, with **NPS 1/2 (DN 50)**, threaded, pressure-gauge connection.
 - c. Stuffing Box: Cast iron with packing rings, pressure-relief connection, stainless steel packing gland, bronze bearing, and rubber slinger.

- d. Line Shaft: Stainless steel in sections **10 ft. (3 m)** or less, with left-hand threaded-steel couplings, centering spiders, and fluted rubber bearings.
 - e. Line Shaft Bearings: Bronze, water lubricated.
 - f. Bowl Section: Multiple close-grained, flanged cast-iron bowls.
 - 1) Intermediate bowls with enamel- or epoxy-lined waterways for maximum efficiency and wear protection and of identical design for interchangeability.
 - 2) Bowls fitted with **[bronze][neoprene]** bearings.
 - g. Impeller: Closed type, **[silicon bronze][stainless steel]** dynamically balanced and securely fastened to bowl.
 - h. Suction Bell: Close-grained cast-iron bowl with bronze bearing and bronze sand collar.
 - i. Wear Rings: Bronze located in the suction and intermediate bowls and with minimum clearance to the impeller surface.
 - j. Column Pipe: ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded sleeve couplings or rabbet fit flange ends in sections **10 ft. (3 m)** or less.
 - k. Suction Strainer: Cast or fabricated; bronze, stainless steel, or Monel; and sized to restrict passage of **1/2-inch (13-mm)** spheres.
9. Right-Angle Gear Drive: FM-Approved, speed-reduction gear drive for pump speed control. Provide ratio for outlet speed of approximately 1760 rpm.
 10. Engine-to-Gear Drive Shaft: FM-Approved, telescoping, steel drive shaft with universal joint and grease fitting at each end. Include metal shaft guard.
 11. Capacities and Characteristics:
 - a. Rated Capacity: **<Insert gpm (L/minute)>**.
 - b. Total Rated Head: **<Insert feet or psig (kPa)>**.
 - c. Inlet Column Size: **<Insert NPS (DN)>**.
 - d. Pump Column Length: **<Insert feet (m)>**.
 - e. Pump Head Outlet Flange: **[Class 125][Class 250]<Insert class>**.
 - f. Suction Head Available at Pump: **<Insert feet (m)>**.
 - g. Engine Horsepower: **<Insert number>** hp.
 - h. Engine Speed: **<Insert number>** rpm.
 - i. Fuel Tank Capacity: **<Insert gal. (L)>**.
 - j. Right-Angle Gear-Drive Speed-Reduction Ratio: **[1:1][2:1]<Insert ratio>**.
 - k. Right-Angle Gear-Drive Outlet and Pump Speed: **<Insert number>** rpm.
 - l. Pump-Start, Pressure-Switch Setting: **<Insert psig (kPa)>**.
 - m. Pump-Stop, Pressure-Switch Setting: **<Insert psig (kPa)>**.
 12. Source Quality Control:
 - a. Manufacturer Testing: Test and inspect fire pumps in accordance with UL 448 requirements for operation test and manufacturing and production tests.
 - 1) Verification of Performance: Rate fire pumps in accordance with UL 448.
 - b. Prepare test and inspection reports.

2.3 DIESEL ENGINE DRIVER

A. Diesel Engine Driver:

1. Fuel: Fuel oil, **[Grade DF-2]<Insert grade>**.
2. Horsepower Rating: Not less than 110 percent of maximum brake horsepower (after derating for temperature and elevation in accordance with NFPA 20).



3. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.
4. Controls:
 - a. Adjustable governor.
 - b. Over-speed shutdown.
 - c. Manual reset, speed switch.
 - d. Instrument panel with tachometer, oil pressure gauge, water temperature gauge, and hour meter.
5. Fuel System:
 - a. Comply with NFPA 20.
 - b. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 - c. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
 - d. Flexible metallic fuel lines.
 - e. Inline fuel filter.
 - f. Oil pressure safety switch.
 - g. Air cleaner.
 - h. Engine-driven oil pump.
 - i. Enclosed control wiring electric starter with voltage regulator.
 - j. Storage Tank: **[Double-Wall,]** size indicated, but not less than required by NFPA 20; with floor legs, direct-reading level gauge[, and secondary containment tank having capacity at least equal to storage tank].
6. Exhaust System:
 - a. Piping: ASTM A53/A53M, Type E or Type S, Schedule 40 black steel pipe; ASME B16.9 weld-type pipe fittings; ASME B16.5 steel flanges; and ASME B16.21 nonmetallic gaskets.
 - b. Fabricate double-wall, ventilated thimble from steel pipe.
 - c. Flexible exhaust connector.
 - d. **[Industrial-][Residential-][Critical-][Super Critical-][Hospital-][Hospital Plus-][Extreme-]** grade exhaust silencer with spark arrestor.
7. Rated Engine Speed: 1800 rpm.
8. Maximum Piston Speed for Four-Cycle Engines: **2250 fpm (11.4 m/s)**.
9. Engine- or Skid-Mounted Lubrication System:
 - a. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 - b. Thermostatic Control Valve: Controls flow in system to maintain optimum oil temperature. Unit is to be capable of full flow and is designed to be fail-safe.
 - c. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
10. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system.
11. Cooling System, Factory-Mounted Radiator:
 - a. Factory installed, closed loop, liquid cooled, with radiator factory mounted on fire-pump mounting frame and integral engine-driven coolant pump.
 - b. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 - c. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to

- 110 percent load condition.
 - d. Expansion Tank: Constructed of welded-steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gauge glass and petcock.
 - e. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 - f. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - 1) Rating: **50-psig (345-kPa)** maximum working pressure, with coolant at **180 deg F (82 deg C)**, and noncollapsible under vacuum.
 - 2) End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
12. Cooling System, Remote Radiator:
 - a. Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump.
 - b. Configuration: **[Vertical][Horizontal]** air discharge.
 - c. Radiator Core Tubes: **[Aluminum][Nonferrous-metal construction other than aluminum]**.
 - d. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 - e. Expansion Tank: Constructed of welded-steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 - f. Fan: Driven by **[multiple belts from engine shaft][totally enclosed electric motor with sealed bearings]**.
 - g. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 - h. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
13. Muffler/Silencer, Industrial Grade: Sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of **[15 dBA]<Insert dBA>** at 500 Hz.
 - b. Sound level measured at a distance of **[25 ft. (8 m)]<Insert distance>** from exhaust discharge after installation is complete is to be **[85]<Insert number>** dBA or less.
14. Muffler/Silencer, Residential Grade: Sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of **[20 dBA]<Insert dBA>** at 500 Hz.
 - b. Sound level measured at a distance of **[10 ft. (3 m)]<Insert distance>** from exhaust discharge after installation is complete is to be **[85]<Insert number>** dBA or less.
15. Muffler/Silencer, Critical Grade: Sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of **[25 dBA]<Insert dBA>** at 500 Hz.
 - b. Sound level measured at a distance of **[10 ft. (3 m)]<Insert distance>** from exhaust discharge after installation is complete is to be **[85]<Insert number>** dBA or less.

16. Muffler/Silencer, Super Critical Grade: Sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of **[30 dBA]<Insert dbA>** at 500 Hz.
 - b. Sound level measured at a distance of **[10 ft. (3 m)]<Insert distance>** from exhaust discharge after installation is complete is to be **[85]<Insert number>** dBA or less.
17. Muffler/Silencer, Hospital Grade: Sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of **[35 dBA]<Insert dBA>** at 500 Hz.
 - b. Sound level measured at a distance of **[10 ft. (3 m)]<Insert distance>** from exhaust discharge after installation is complete is to be **[85]<Insert number>** dBA or less.
18. Muffler/Silencer, Hospital Plus Grade: Sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of **[35 dBA]<Insert dBA>** at 500 Hz.
 - b. Sound level measured at a distance of **[10 ft. (3 m)]<Insert distance>** from exhaust discharge after installation is complete is to be **[85]<Insert number>** dBA or less.
19. Muffler/Silencer, Extreme Grade: Sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of **[40 dBA]<Insert dBA>** at 500 Hz.
 - b. Sound level measured at a distance of **[10 ft. (3 m)]<Insert distance>** from exhaust discharge after installation is complete is to be **[85]<Insert number>** dBA or less.
20. Muffler/Silencer, Super Extreme Grade: Sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of **[45 dBA]<Insert dBA>** at 500 Hz.
 - b. Sound level measured at a distance of **[10 ft. (3 m)]<Insert distance>** from exhaust discharge after installation is complete is to be **[85]<Insert number>** dBA or less.
21. Air-Intake Filter: **[Standard][Heavy]**-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
22. Starting System: **[12][24]** V dc, with negative ground.
 - a. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
 - b. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 - c. Cranking Cycle: **[60]<Insert number>** seconds.
 - d. Battery: Adequate capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least **[twice][three times]** without recharging.
 - e. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
 - f. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal

insulation. Thermostatically controlled heater is to be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place.

- g. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35 A minimum continuous rating.
- h. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit is to comply with UL 1236 and include the following features:
 - 1) Operation: Equalizing-charging rate of 10 A is to be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit is to then be automatically switched to a lower float-charging mode and continue to operate in that mode until battery is discharged again.
 - 2) Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - 3) Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - 4) Ammeter and Voltmeter: Flush mounted in door. Meters are to indicate charging rates.
 - 5) Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition closes contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - 6) Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.4 FIRE-PUMP CONTROLLERS - FOR DIESEL-DRIVE FIRE PUMPS

A. Fire-Pump Controllers - For Diesel-Drive Fire Pumps:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Eaton]**
 - b. **[Firetrol]**
 - c. **[Master Control Systems, Inc]**
 - d. **[Metron Eledyne; a Hubbell Company]**
 - e. **[Tornatech]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Firetrol]**
 - c. **[Master Control Systems, Inc]**
 - d. **[Metron Eledyne; a Hubbell Company]**
 - e. **[Tornatech]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations:



- a. Obtain diesel-drive controllers from single manufacturer.
 - b. Equipment provider is to provide services of a factory authorized service representative and have a service facility located within a **60-mile (100 km)** radius of Project site.
4. Description:
 - a. Factory fabricated, assembled, wired, and tested.
 - b. Operation: **[Combined automatic and nonautomatic][Nonautomatic]**.
5. Standards:
 - a. Comply with NFPA 20.
 - b. **<Insert standard>**.
6. Method of Starting:
 - a. Actuation: **[Pressure][Nonpressure]**-switch actuated.
 - 1) Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
 - 2) Programmable minimum-run-time relay to prevent short cycling.
 - 3) Programmable timer for weekly tests.
 - b. Dual, redundant dc-voltage battery units, with automatic changeover.
 - c. Emergency Control: Bypasses automatic control circuits during manual starting and running.
 - d. Automatic engine start on loss of ac power to the controller.
7. Method of Stopping: **[Automatic and nonautomatic shutdown after automatic starting][Nonautomatic]**.
8. Enclosure:
 - a. NEMA 250, **[Type 2][Type 3R][Type 4][Type 4X][Type 12]<Insert type>** minimum.
 - 1) Comply with environmental conditions at installed location and NFPA 20.
 - b. Enclosure Color: **[Manufacturer's standard "fire-pump-controller red"]<Insert color>**.
 - c. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.
 - d. Features:
 - 1) Floor stands, **12 inches (305 mm)** high, for floor-mounted controllers.
 - 2) Space heater, **[120 V ac][240 V ac][, with humidistat][, with thermostat]**.
 - 3) Tropicalization.
 - 4) **<Insert optional feature>**.
9. Door-Mounted Operator Interface and Controls:
 - a. Monitor, display, and control devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
 - 1) Pressure and event recorder capable of logging pressure data and operational events with time and date stamp for the life of the controller. Data is to be retrievable

and downloadable to a flash memory drive via a USB port accessible to the user without having to open the controller door.

- b. Touch Screen Operator Interface:
 - 1) Provide minimum **7-inch (178-mm)** LCD color touch screen powered by an embedded microprocessor with software.
 - 2) In addition to push-button operation for START/STOP/RUN TEST and graphic display of system operations, the control is to allow programming of cut-in and cut-out pressures and minimum runtime is to allow for onscreen viewing of corresponding Owner's Manual in chosen language.
- c. Local and Remote Alarm and Status Indications:
 - 1) Status LEDs - green color for the following:
 - a) Low pressure.
 - b) Engine run.
 - c) Remote start.
 - d) Interlock on.
 - e) Deluge valve (if applicable).
 - f) One programmable LED.
 - 2) Alarm LEDs - red color for the following:
 - a) Battery #1 failure.
 - b) Charger #1 failure.
 - c) Battery #2 failure.
 - d) Charger #2 failure
 - e) Low pressure.
 - f) System overpressure.
 - g) Low suction pressure.
 - h) Low fuel.
 - i) Fail to start.
 - j) High engine temperature.
 - k) Low oil pressure.
 - l) Engine overspeed.
 - m) ECM selector in alternative position.
 - n) Fuel injection malfunction.
 - o) ECM warning.
 - p) ECM failure.
 - q) High raw water temperature.
 - r) Low engine temperature
 - s) Fuel spill
 - t) One programmable LED.
- d. Audible alarm with PUSH TO SILENCE button.
- e. Nonautomatic START and STOP push buttons or switches.
- f. Set pressure and system pressure.
- g. **<Insert function>**.

10. Features:

- a. Extra Output Contacts:
 - 1) **[One]<Insert number>** Form C contacts for low pump-room temperature.

- 2) **[One]<Insert number>** each, Form C contacts for high and low fuel levels.
 - 3) **[One]<Insert number>** each, Form C contacts for high and low reservoir levels.
 - 4) **<Insert contact type>**.
- b. Operator Interface Communications Ports: USB, Ethernet, and complying with ANSI/TIA/EIA-485-A.
 - c. Communications Protocol Capability: Modbus with TCP/IP frame format and shielded female RJ45 connector.
 - d. Powered louver contacts.
 - e. Powered engine-oil heater contacts.
 - f. **<Insert optional feature>**.
11. Battery Charger System:
- a. Built-in, independent, dual battery chargers with automatic changeover; **[12 V dc][24 V dc]** for **[lead-acid][nickel-cadmium]** batteries.
 - b. Standard: **[UL 1236]<Insert standard>**.
12. Source Quality Control:
- a. Manufacturer Testing: Test and inspect fire-pump controllers in accordance with requirements in NFPA 20 and **[UL 218]<Insert standard>**.
 - 1) Verification of Performance: Rate controllers in accordance with operation of functions and features specified.
 - b. Prepare test and inspection reports.

2.5 FIRE-PUMP ACCESSORIES AND SPECIALTIES

- A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump discharge piping.
- B. Circulation Relief Valves: UL 1478, bronze or cast iron, spring loaded; for installation in pump-discharge piping.
- C. Outlet Fitting: Concentric tapered reducer at pump-head-discharge outlet.
- D. Discharge Cone: **[Closed][Open][Closed or open]** type.
- E. Fire-Pump Relief Valve:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[BERMAD Control Valves]**
 - b. **[CLA-VAL]**
 - c. **[Kunkle Valve]**
 - d. **[OCV Control Valves]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[BERMAD Control Valves]**
 - b. **[CLA-VAL]**
 - c. **[Kunkle Valve]**
 - d. **[OCV Control Valves]**
 - e. **[WATTS; A Watts Water Technologies Company]**
 - f. **[Zurn Industries, LLC]**
 - g. **<Insert manufacturer's name>**
3. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.

F. Fire-Pump Test Connection:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Fire Supply]**
 - b. **[CLA-VAL]**
 - c. **[Croker; a Division of Morris Group International]**
 - d. **[Guardian Fire Equipment, Inc]**
 - e. **[Potter Roemer LLC; a Division of Morris Group International]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Fire Supply]**
 - b. **[CLA-VAL]**
 - c. **[Croker; a Division of Morris Group International]**
 - d. **[Guardian Fire Equipment, Inc]**
 - e. **[Potter Roemer LLC; a Division of Morris Group International]**
 - f. **<Insert manufacturer's name>**
3. Standards:
 - a. NFPA 20.
 - b. UL 405, except outlets without clappers instead of inlets.
4. Description: **[Exposed, projecting, for wall mounting][Flush, for wall mounting]<Insert type>**.
5. Pressure Rating: **175 psig (1200 kPa)** minimum.
6. Body Material: Corrosion-resistant metal with number of outlets required by NFPA 20.
7. Escutcheon Plate: Brass or bronze.
8. Hose Valves: UL 668, bronze, with outlet threaded in accordance with NFPA 1963 and matching local fire-department threads. Include caps and chains.
9. Exposed Parts Finish: **[Polished][Rough][brass][, chrome plated]**.
10. Escutcheon Plate Marking: **[FIRE-PUMP TEST CONNECTION]<Insert marking>**.

G. Fire-Pump Flowmeter Systems:



1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Fire Research Corp]**
 - b. **[Gerand Engineering Co]**
 - c. **[Hyspan Precision Products, Inc]**
 - d. **[Victaulic Company]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Fire Research Corp]**
 - b. **[Gerand Engineering Co]**
 - c. **[Hyspan Precision Products, Inc]**
 - d. **[Victaulic Company]**
 - e. **<Insert manufacturer's name>**
3. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.
4. Pressure Rating: **[175 psig (1200 kPa) minimum][250 psig (1725 kPa)]**.
5. Sensor: **[Venturi][Paddlewheel]<Insert type>**. Sensor size is to match pipe, tubing, flowmeter, and fittings.
6. Permanently Mounted Flowmeter: Compatible with flow sensor, with dial not less than **4-1/2 inches (115 mm)** in diameter. **[Include bracket or device for wall mounting.]**
 - a. Tubing Package: **NPS 1/8 or NPS 1/4 (DN 6 or DN 10) [soft copper][or][plastic]** tubing with copper or brass fittings and valves.
7. Portable Flowmeter: Compatible with flow sensor, with dial not less than **4-1/2 inches (115 mm)** in diameter and with two **12-foot- (3.7-m-)** long hoses in carrying case.

2.6 FUEL OIL STORAGE

- A. Comply with NFPA 30.
- B. Day Tank: UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
 1. Containment: Integral rupture basin, with a capacity of 150 percent of nominal capacity of day tank.
 - a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
 2. Tank Capacity: **[As recommended by engine manufacturer]<Insert gallons (liters)>**.
 3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
 4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
 5. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel



fill, vent line, and overflow line; and tank drain line with shutoff valve.

- C. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank level indicator.
2. Capacity: Fuel for **[eight]<Insert number>** hours' continuous operation at 100 percent rated power output.
3. Vandal-resistant fill cap.
4. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.7 FIRE-PUMP CONTROLLER REMOTE ALARM PANEL

- A. Fire-Pump Controller Remote Alarm Panel:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Eaton]**
 - b. **[Firetrol]**
 - c. **[Master Control Systems, Inc]**
 - d. **[Metron Eledyne; a Hubbell Company]**
 - e. **[Tornatech]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Firetrol]**
 - c. **[Master Control Systems, Inc]**
 - d. **[Metron Eledyne; a Hubbell Company]**
 - e. **[Tornatech]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain remote alarm panels from single manufacturer.
4. Standards:
 - a. Comply with NFPA 20.
 - b. **<Insert standard>**.
5. Description: Factory fabricated, assembled, wired, and tested.
6. Supervisory and Normal Control Voltage: **[120 V ac][240 V ac]<Insert voltage>; [single][dual]** source.
7. Audible and Visual Alarm and Status Indications for Diesel-Driven Pump Controllers:
 - a. Normal power on.
 - b. Supervisory power on.
 - c. Engine running.
 - d. Not in automatic mode.
 - e. Low fuel.
 - f. Common alarm.

- g. <Insert alarm>.
- h. <Insert alarm> with SPDT, 8 ampere relay output.

8. Audible alarm, with SILENCE push button.

2.8 GROUT

- A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink and recommended for interior and exterior applications.
- C. Design Mix: **5000 psi (34 MPa)**, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces to receive equipment, equipment bases and anchorage provisions, with installing contractor(s), **[Architect][engineer][Construction Manager][and]** Manufacturer's Representative present, for compliance with requirements for installation tolerances and other conditions affecting performance of the fire pump and fire-pump controller.
- B. Examine roughing-in for fire-suppression piping systems to verify actual locations of piping connections before fire-pump installation.
- C. Examine equipment before installation. Reject equipment that is wet or damaged by moisture or mold.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PROTECTION OF FIRE-PUMP CONTROLLERS

- A. Temporary Heating: Apply temporary heat to maintain temperature in accordance with manufacturer's written instructions until enclosed fire-pump controllers are ready to be energized and placed into service.
- B. Replace fire-pump controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.3 INSTALLATION OF FIRE PUMPS

- A. Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
- B. Equipment Mounting:
 - 1. Install fire pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria."
 3. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."
- C. Install fire-pump discharge piping equal to or larger than size required by NFPA 20.
 - D. Support piping and pumps separately, so weight of piping does not rest on pumps.
 - E. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Section 211000 "Water-Based Fire-Suppression Systems."
 - F. Install pressure gauges on fire-pump suction and pump-head discharge flange pressure-gauge tapping. Comply with requirements for pressure gauges specified in Section 211000 "Water-Based Fire-Suppression Systems."
 - G. Install piping hangers and supports, anchors, valves, gauges, and equipment supports in accordance with NFPA 20 **[NFPA 13][and][NFPA 14]<Insert standard>**.
 - H. Install fuel system in accordance with NFPA 20.
 - I. Install water supply and drain piping for diesel-engine heat exchangers. Extend drain piping from heat exchangers to point of disposal.
 - J. Install exhaust-system piping for diesel engines. Extend to point of termination outside structure. Install pipe and fittings with welded joints; install components having flanged connections with gasketed joints.
 - K. Install condensate drain piping for diesel-engine exhaust system. Extend drain piping from low points of exhaust system to condensate traps and to point of disposal.
 - L. Install flowmeters and sensors. Install flowmeter-system components and make connections in accordance with NFPA 20 and manufacturer's written instructions.
 - M. Electrical Wiring: Install electrical devices furnished by equipment manufacturers that are not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

3.4 ALIGNMENT OF FIRE PUMPS

- A. Align fire-pump-driver, right-angle gear-drive, and fire-pump shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
- B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
- C. Align piping connections.
- D. Align pump and driver shafts for angular and parallel alignment in accordance with HI 2.4 and to tolerances specified by manufacturer.

3.5 PIPING CONNECTIONS

- A. Comply with requirements for piping and valves specified in Section 211000 "Water-Based Fire-Suppression Systems." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps and equipment to allow service and maintenance.
- C. Connect relief-valve discharge to drainage piping or point of discharge.
- D. Connect flowmeter-system meters, sensors, and valves to tubing.
- E. Connect fire pumps to their controllers.

3.6 INSTALLATION OF FIRE-PUMP CONTROLLERS

- A. Coordinate installation of controllers with other construction, including conduit, piping, fire-pump equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels. Ensure that controllers are within sight of fire-pump drivers.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.
- C. Install controllers within sight of their respective drivers.
- D. Connect controllers to their dedicated pressure-sensing lines.
- E. Wall-Mounting Controllers: Install controllers on walls with disconnect operating handles not higher than **79 inches (2 m)** above finished floor, and bottom of enclosure not less than **12 inches (305 mm)** above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."
- F. Floor-Mounting Controllers: Install controllers on concrete base(s), using floor stands high enough so that the bottom of enclosure cabinet is not less than **12 inches (305 mm)** above finished floor. Comply with requirements for concrete bases specified in Section 260529 "Hangers and Supports for Electrical Systems."
 - 1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - 2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 3. Install anchor bolts to elevations required for proper attachment to supported equipment.
- G. Seismic Bracing: Comply with requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems" And Section 018123 "Facility Seismic and Wind Criteria."
- H. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- I. Installation of Control and Alarm Wiring:
 - 1. Install wiring between fire-pump controllers and remote devices[**and facility's central monitoring system**]. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."

2. Install wiring between remote alarm panels and fire-pump controllers. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."
3. Install wiring between controllers and the building's fire-alarm system. Comply with requirements specified in Section 284600 "Fire Detection and Alarm."
4. Bundle, train, and support wiring in enclosures.
5. Connect remote manual and automatic activation devices where applicable.

J. Field-Acceptance Testing and Inspection:

1. Acceptance Testing Preparation:
 - a. Inspect and Test Each Component:
 - 1) Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
 - 2) Test insulation resistance for each element, component, connecting supply, feeder, and control circuits.
 - 3) Test continuity of each circuit.
2. Representatives from manufacturers of fire-pump controllers must be present during acceptance tests and inspections in accordance with NFPA 20.
3. Acceptance tests and inspections must be witnessed by **[Architect][Construction Manager][Owner][authorities having jurisdiction]<Insert names or titles of witnesses>**.
4. Acceptance Tests and Inspections:
 - a. Do not begin field-acceptance testing until suction piping has been flushed and hydrostatically tested and the certificate for flushing and testing has been submitted to **[Architect][Construction Manager][Owner]** and authorities having jurisdiction.
 - b. Prior to starting, notify authorities having jurisdiction of the time and place of the acceptance testing.
 - c. Engage manufacturer's factory-authorized service representative to be present during the testing.
 - d. Perform field-acceptance tests in accordance with NFPA 20.
5. Nonconforming Work:
 - a. Controllers will be considered defective if they do not pass tests and inspections.
 - b. Remove and replace defective units with new units and retest.
6. Prepare and submit field-acceptance testing and inspection reports.

3.7 INSTALLATION OF FIRE-PUMP CONTROLLER REMOTE ALARM PANEL

- A. Install panels on walls with tops not higher than **[72 inches (1829 mm)]<Insert height>** above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For panels not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

3.8 IDENTIFICATION OF FIRE PUMPS AND FIRE-PUMP CONTROLLERS

- A. Comply with NFPA 20 requirements for marking of fire pumps and fire-pump controllers.
- B. Identify equipment, system components, piping, wiring, cabling, and terminals. Comply with requirements for identification in NFPA 20 and as specified in Section 210553 "Identification for Fire-

Suppression Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

3.9 STARTUP SERVICE FOR FIRE PUMPS AND CONTROLLER

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. **<Insert startup steps>**.

3.10 ADJUSTING

- A. Adjust fire-pump controllers and battery charger systems to function smoothly and as recommended by manufacturer.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, and timers.
- C. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- D. Set field-adjustable pressure switches.

3.11 FIELD QUALITY CONTROL

- A. Test each fire pump with its right-angle gear drive and controller as a unit.
- B. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. After installing components, assemblies, and equipment, including controller, test for compliance with requirements.
 - 2. Test in accordance with NFPA 20 for acceptance and performance testing.
 - a. Prior to initial startup and acceptance testing, complete and check all electric wiring serving fire-pump controller and pressure-maintenance pump motor, including control interwiring, normal power, and alternate power.
 - 3. Leak Test: After installation, fill system and test for leaks. Repair leaks and retest until no leaks exist.
 - 4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Components, assemblies, and equipment will be considered defective if they do not pass tests and



inspections.

- F. Prepare test and inspection reports.
- G. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.12 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain fire pumps, right-angle gear drives, and fire-pump controllers.

END OF SECTION 23 21 23 23A



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 21 23 23	23 21 00 00	Underground Hydronic Piping
23 21 23 23	23 21 23 00	Hydronic Pumps
23 21 29 00	23 21 00 00	Underground Hydronic Piping
23 21 29 00	23 21 23 00	Hydronic Pumps



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 22 00 00 - UNDERGROUND STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel pipe and fittings.
2. Fiberglass pipe and fittings.
3. Preengineered conduit piping system.
4. Loose-fill insulation.

1.2 DEFINITIONS

- A. HP Systems: High-pressure piping operating at more than **15 psig (104 kPa)** as defined by ASME B31.1.
- B. Invert: Vertical distance from Project datum reference point to bottom of interior pipe surface.
- C. LP Systems: Low-pressure piping operating at **15 psig (104 kPa)** or less as defined by ASME B31.1.
- D. Reinforced, Thermosetting Resin Fitting (RTRF): Fittings fabricated of composite materials, largely consisting of a reinforcement material embedded in, or surrounded by, cured thermosetting resin. Most common form of reinforced thermosetting resin pipe is one in which fiberglass strands form reinforcement.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

B. Shop Drawings: For underground steam and condensate distribution piping. Signed and sealed by a qualified professional engineer.

1. Include calculations showing requirements for expansion compensation for underground piping.
2. Show expansion compensators, offsets, and loops with appropriate materials to allow piping movement in the required locations. Show anchors and guides that restrain piping movement with calculated loads, and show concrete thrust block dimensions.
3. Show pipe sizes, locations, inverts, and pitch. Show piping in trench and piping in conduit, with details showing clearances between piping.
4. Show insulation thickness.

C. Delegated Design Submittals: For underground steam and condensate piping systems indicated to comply with performance requirements and design criteria, including analysis data and design drawings signed and sealed by the professional engineer responsible for their preparation.

1. Include design calculations and details for selecting thermal expansion and thrust restraints.



1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from steam distribution piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
- B. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than **1 inch equals 50 feet (1:500)** and at vertical scale of not less than **1 inch equals 5 feet (1:50)**.
 - 1. Show locations and inverts of utility system manholes and piping. Show types, sizes, materials, and inverts of other utilities crossing steam distribution piping.
 - 2. Show depth of cover from top of steam distribution system piping to finished grade.
- C. Qualification Data: For Installer.
- D. Welding certificates.
- E. Material Test Reports: For conduit piping, by a qualified testing agency.
- F. Source quality-control reports.
- G. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Fiberglass Pipe and Fitting Installers: Provide RTRF and RTRP pipe installation by technicians certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with provisions in **[ASME B31.9][ASME B31.1]**.
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. ASME Compliance:
 - 1. Comply with **[ASME B31.9][ASME B31.1]** for materials, products, and installation.
 - 2. Provide safety valves and pressure vessels bearing appropriate ASME labels.

1.6 FIELD CONDITIONS

- A. Interruption of Existing Utilities: Do not interrupt utilities serving occupied facilities unless permitted under the following conditions and then only after arranging to provide temporary utility services in accordance with requirements indicated:
 - 1. Notify **[Architect][Construction Manager][Owner]** no fewer than **[two]<Insert number>** days in advance of proposed interruption of utility.
 - 2. Do not proceed with interruption of utility without **[Architect's][Construction Manager's][Owner's]** written permission.

1.7 COORDINATION

- A. Coordinate pipe-fitting pressure classes with products specified in related Sections.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing steam and condensate piping systems with the following minimum working-pressure ratings:
1. HP Steam Piping: **<Insert psig (kPa)>**.
 2. LP Steam Piping: **<Insert psig (kPa)>**.
 3. Condensate Piping: **<Insert psig (kPa)>** at **[250 deg F (121 deg C)]<Insert temperature>**.
- B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design underground steam and condensate piping systems, including restraints and anchors.

2.2 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M, black steel, plain ends, welded and seamless, Grade B, black with plain ends; wall thickness as indicated in "Piping Application" Article.
- B. Cast-Iron, Threaded Fittings: ASME B16.4, standard pattern, with threads in accordance with ASME B1.20.1; Classes 125, 150, and 300 as indicated in "Piping Application" Article.
- C. Malleable-Iron, Threaded Fittings: ASME B16.3, ASME B1.20.1; Classes 150 and 300 as indicated in "Piping Application" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Application" Article.
- E. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
1. Material Group: 1.1.
 2. End Connections: Butt welding.
 3. Facings: Raised face.
- F. Steel Welding Fittings: **[ASME B16.9][and][ASTM A234/A234M]**, seamless or welded.
1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Nipples: ASTM A733, standard weight, seamless, carbon-steel pipe complying with ASTM A53/A53M.
- H. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
1. ASME B16.21, nonmetallic, flat, asbestos free, **1/8-inch (3.2-mm)** maximum thickness unless thickness or specific material is indicated.



- a. Full-Face Type: For flat face, Class 125, cast-iron and cast-bronze flanges.
- b. Narrow-Face Type: For raised face, Class 250, cast-iron and steel flanges.

- I. Flange Bolts and Nuts: ASME B18.2.1 carbon steel, unless otherwise indicated.

2.3 FIBERGLASS PIPE AND FITTINGS

- A. RTRP: ASTM D2996, filament-wound pipe with tapered bell-and-spigot ends for adhesive joints.
- B. RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.
- C. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.
- D. Flanges: ASTM D4024. Full-face gaskets suitable for service, minimum **1/8-inch- (3.2-mm-)** thick, 60-70 durometer. ASTM A307, Grade B, hex-head bolts with washers.

2.4 PREENGINEERED CONDUIT PIPING SYSTEM

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- 1. **[Insul-Tek Piping Systems, Inc]**
- 2. **[PermAlert]**
- 3. **[Rovanco Piping Systems, Inc]**
- 4. **[Thermacor Process, L.P.]**
- 5. **[Tricon Piping Systems, Inc.]**
- 6. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1. **[Insul-Tek Piping Systems, Inc]**
- 2. **[PermAlert]**
- 3. **[Rovanco Piping Systems, Inc]**
- 4. **[Thermacor Process, L.P.]**
- 5. **[Tricon Piping Systems, Inc.]**
- 6. **<Insert manufacturer's name>**

- C. Description: Factory-fabricated and -assembled, airtight and watertight, drainable, pressure-tested piping with conduit, inner pipe supports, and insulated carrier piping. Fabricate so insulation can be dried in place by forcing dry air through conduit.

- D. Source Limitations: Obtain piping system from single source from single manufacturer.

- E. Carrier Pipe: Material as indicated in "Piping Application" Article. See Part 3 articles in this Section for required carrier pipe.

- F. Carrier Pipe Insulation:

- 1. Mineral-Wool Pipe Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply

with ASTM C547, [**Type I, 850 deg F (454 deg C)**][**Type II, 1200 deg F (649 deg C)**], Grade A.

- a. Bands: ASTM A666, Type 304, stainless steel, **3/4 inch (19 mm)** wide, **0.020 inch (0.5 mm)** thick.
2. Calcium Silicate Pipe Insulation: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a nonasbestos fibrous reinforcement. Comply with ASTM C533, Type I.
 - a. Bands: ASTM A666, Type 304, stainless steel, **3/4 inch (19 mm)** wide, **0.020 inch (0.5 mm)** thick.
3. Polyisocyanurate Foam Pipe Insulation: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
 - a. Comply with ASTM C591, Type I or Type IV, except thermal conductivity (k-value) to not exceed **0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K)** at **75 deg F (24 deg C)** after 180 days of aging.
 - b. Flame-spread index to be 25 or less and smoke-developed index to be 50 or less for thickness up to **1-1/2 inches (38 mm)**, as tested in accordance with ASTM E84.
 - c. Fabricate shapes in accordance with ASTM C450 and ASTM C585.
4. Polyurethane Foam Pipe Insulation: Unfaced, preformed, rigid cellular polyurethane material intended for use as thermal insulation.
 - a. Comply with ASTM C591, Type I or Type IV, except thermal conductivity (k-value) to not exceed **0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K)** at **75 deg F (24 deg C)** after 180 days of aging.
 - b. Flame-spread index to be 25 or less and smoke-developed index to be 50 or less for thickness up to **1-1/2 inches (38 mm)**, as tested in accordance with ASTM E84.
 - c. Fabricate shapes in accordance with ASTM C450 and ASTM C585.

G. Minimum Clearance:

1. Between Carrier Pipe Insulation and Conduit: **1 inch (25 mm)**.
2. Between Insulation of Multiple Carrier Pipes: **3/16 inch (4.75 mm)**.
3. Between Bottom of Carrier Pipe Insulation and Conduit: **1 inch (25 mm)**.

H. Conduit: [Spiral wound, steel]<Insert conduit material>.

1. Finish: With two coats of fusion-bonded epoxy, minimum **20 mils (0.50 mm)** thick.
2. Cover: With polyurethane foam insulation with an HDPE jacket; thickness indicated in "Piping Application" Article.
3. Piping Supports within Conduit: Corrugated galvanized steel with a maximum spacing of **10 feet (3 m)**.
4. Fittings: Factory-fabricated and -insulated elbows and tees. Elbows may be bent pipe equal to carrier pipe. Tees to be factory fabricated and insulated, and compatible with carrier pipe.
5. Expansion Offsets and Loops: Provide directional changes to permit piping expansion without exceeding allowable pipe stress.
6. Accessories include the following:
 - a. Water Shed: Terminal end protector for carrier pipes entering building through floor, **3 inches (75 mm)** deep and **2 inches (50 mm)** larger than conduit; terminate conduit **20 inches (500 mm)** above the floor level.
 - b. Guides and Anchors: Steel plate welded to carrier pipes and to conduit, complete with vent and drainage openings inside conduit.



- c. End Seals: Steel plate welded to carrier pipes and to conduit, complete with drain and vent openings on vertical centerline.
- d. Gland Seals: Packed stuffing box and gland follower mounted on steel plate, welded to end of conduit, permitting axial movement of carrier piping, with drain and vent connections on vertical centerline.
- e. Joint Kit: Half-shell, pourable or split insulation and shrink-wrap sleeve.

I. Manholes: Black steel with lifting eyes.

- 1. Finish: Spray-applied urethane, minimum **30 mils (0.75 mm)** thick.
- 2. Access: **30-inch- (750-mm-)** diameter waterproof cover with gasket, ladder, and two **6-inch (150-mm)** vents, one high and one low, extending above grade with rain caps.
- 3. Conduit Stub-Outs and Seals: Welded steel with drain and vent openings.
- 4. Sump: **12 inches (300 mm)** in diameter; **12 inches (300 mm)** deep.
- 5. Flotation Anchor: Oversized bottom keyed into concrete base.

J. Source Quality Control: Factory test conduit to **15 psig (105 kPa)** for a minimum of two minutes with no change in pressure. Factory test carrier pipe to 150 percent of operating pressure of system. Furnish test certificates.

2.5 LOOSE-FILL INSULATION

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1. **[DriTherm International Inc.]**
- 2. **[Gilsulate International, Inc.]**
- 3. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1. **[DriTherm International Inc.]**
- 2. **[Gilsulate International, Inc.]**
- 3. **<Insert manufacturer's name>**

C. Description: Inorganic, nontoxic, nonflammable, hydrophobic, pour-in-place insulation.

D. Source Limitations: Obtain insulation from single source from single manufacturer.

E. Thermal Conductivity (k-Value): **[0.60 at 175 deg F (0.087 at 79 deg C) and 0.65 at 300 deg F (0.094 at 149 deg C)]<Insert values at rated temperatures>**.

- 1. Application Temperature Range: **[35 to 800 deg F (2 to 426 deg C)]<Insert range>**.

F. Dry Density, Minimum: **[40 to 42 lb/cu. ft. (640 to 672 kg/cu. m)]<Insert range>**.

G. Strength: **[12,000 lb/sq. ft. (58 600 kg/sq. m)]<Insert range>**.

H. Insulation at Pipe Joints and Fittings:

- 1. Provide pipe system manufacturer's recommended joint and fitting seals, with formed, spray, or

loose-fill insulation. Provide pipe system manufacturer's recommended sealants and adhesives required to form watertight boundaries at outer conduit.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. See Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 APPLICATION OF PIPING

A. LP Steam Piping:

1. NPS 2 (DN 50) and Smaller: **[Schedule 40][Schedule 80]**, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
2. NPS 2-1/2 through NPS 12 (DN 65 through DN 300): **[Schedule 40][Schedule 80]**, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
3. NPS 14 through NPS 18 (DN 350 through DN 450): Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
4. NPS 20 (DN 500) and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
5. Conduit Piping: **[Standard weight][Schedule 40][Schedule 80]** steel carrier pipe, with **[mineral-wool][calcium silicate][polyisocyanurate]** carrier-pipe insulation and with **[coated][coated and insulated]** conduit.
 - a. Piping Insulation Thickness: **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>**.
 - b. Conduit Insulation Thickness: **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>**.
 - 1) Insulation: **[Polyisocyanurate][Polyurethane]**.
 - 2) Insulation Thickness: **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>**.
6. Piping with loose-fill insulation.

B. HP Steam Piping:

1. NPS 2 (DN 50) and Smaller: **[Schedule 40][Schedule 80]**, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
2. NPS 2-1/2 through NPS 12 (DN 65 through DN 300): **[Schedule 40][Schedule 80]**, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
3. NPS 14 through NPS 18 (DN 350 through DN 450): Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
4. NPS 20 (DN 500) and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
5. Conduit Piping: **[Standard weight][Schedule 40][Schedule 80]** steel carrier pipe, with **[mineral-wool][calcium silicate][polyisocyanurate]** carrier-pipe insulation and with **[coated][coated and insulated]** conduit.
 - a. Piping Insulation Thickness: **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>**.
 - b. Conduit Insulation Thickness: **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>**.
 - 1) Insulation: **[Polyisocyanurate][Polyurethane]**.

2) Insulation Thickness: [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.

6. Piping with loose-fill insulation.

C. Condensate Piping:

1. [NPS 2 (DN 50)]<Insert pipe size> and smaller to be [either of] the following:

- a. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
- b. RTRP and RTRF with adhesive or flanged joints.

2. [NPS 2-1/2 (DN 65)]<Insert pipe size> and larger to be [either of] the following:

- a. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
- b. RTRP and RTRF with adhesive or flanged joints.

3. Conduit Piping: [Standard weight, steel pipe and fittings][Schedule 40, steel pipe and fittings][Schedule 80, steel pipe and fittings][Fiberglass pipe and fittings] with [mineral-wool][calcium silicate][polyisocyanurate][polyurethane] carrier-pipe insulation and with [coated][coated and insulated] conduit.

- a. Piping Insulation Thickness: [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.
- b. Conduit Insulation Thickness: [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.

4. Piping with loose-fill insulation.

3.3 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Show piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Remove standing water in the bottom of trench.
- C. Bed the pipe on a minimum **6-inch (150-mm)** layer of pipe system manufacturer's recommended granular fill material with a minimum **6-inch (150-mm)** clearance between pipes.
- D. Do not backfill piping trench or insulate piping until field quality-control testing has been completed and results approved.
- E. Install piping at uniform grade of 0.2 percent downward in direction of flow or as indicated.
 - 1. Maintain continuous bedding under piping. Do not leave gaps in pipe bedding, allowing pipe to sag between contact points with the bedding.
- F. Install condensate piping at uniform grade of 0.4 percent downward in direction of flow.
 - 1. Maintain continuous bedding under piping. Do not leave gaps in pipe bedding, allowing pipe to sag between contact points with the bedding.
- G. In conduit pipes, install drain valves at low points and manual air vents at high points.

- H. Install components with pressure rating equal to or greater than system operating pressure.
- I. Install piping in straight lines. Do not bend pipe.
- J. Install fittings for changes in direction and branch connections.
- K. See Section 230500 "Common Work Results for HVAC" for sleeves and mechanical sleeve seals through exterior building walls.
- L. Connect to steam and condensate piping where it passes through the building wall. Steam and condensate piping inside the building is specified in Section 232213 "Steam and Condensate Heating Piping."
- M. See Section 230523.13 "Butterfly Valves for HVAC Piping" for sleeves and mechanical sleeve seals through exterior building walls.
- N. See Section 230523.15 "Gate Valves for HVAC Piping" for sleeves and mechanical sleeve seals through exterior building walls.
- O. Secure anchors and fittings where piping changes direction, and where elsewhere required by manufacturer's written installation instructions, with concrete thrust blocks. Concrete is specified in Section 033000 "Cast-in-Place Concrete."
- P. See Section 134713 "Cathodic Protection" for cathodic devices and connections to piping and conduit systems.
- Q. Apply bitumastic coating to carbon-steel anchors and guides. Pour concrete thrust blocks and anchors. See Section 033000 "Cast-in-Place Concrete" for concrete and reinforcement.
- R. After field quality-control testing is complete, backfill with **6 inches (150 mm)** of clean, granular material in accordance with piping system manufacturer's written instructions. If mechanical compaction is required, manually backfill to **12 inches (300 mm)** before using mechanical-compaction equipment.

3.4 INSTALLATION OF LOOSE-FILL INSULATION

- A. Compact and stabilize bottom of trench and bedding to ensure continuous pipe support.
- B. Remove standing water in the bottom of trench before installing pipe.
- C. Bed pipe on minimum **6-inch (150-mm)** layer of pipe system manufacturer's recommended granular fill material with minimum **6-inch (150-mm)** clearance between pipes.
- D. See Section 312000 "Earth Moving" for requirements of trench backfill materials.
- E. Form insulation trench by excavation or by installing gypsum board side forms to establish required height and width of insulation.
- F. Support piping with proper pitch, separation, and clearance to backfill or side forms using temporary supporting devices that can be removed after backfilling with insulation.
- G. Place insulation and backfill after field quality-control testing has been completed and results approved.
- H. Insulate piping joints at fittings, expansion loops, and offsets with manufacturer-supplied joint insulation kit. Install insulation of thickness appropriate for calculated expansion amount.

- I. Pour loose-fill insulation to required dimension agitating insulation to eliminate voids around piping.
- J. Maintain pipe system manufacturer's recommended separation between adjacent and crossing pipes and other utilities.
- K. Remove temporary hangers and supports.
- L. Cover loose-fill insulation with polyethylene sheet minimum of **4 mils (0.10 mm)** thick, and empty loose-fill insulation bags on top.
- M. Manually backfill **6 inches (150 mm)** of clean fill. If mechanical compaction is required, manually backfill to **12 inches (300 mm)** before using mechanical-compaction equipment. Do not compact fill with excavating machinery buckets, wheels, or treads.

3.5 JOINT CONSTRUCTION

- A. See Section 330500 "Common Work Results for Utilities" for basic piping joint construction.
- B. Join pipe and fittings in accordance with the following requirements and Section 232213 "Steam and Condensate Heating Piping":
 - 1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1 or ISO 7-1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified processes and welding operators in accordance with "Quality Assurance" Article.
- E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Apply suitable lubricants on bolt threads.
- F. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join in accordance with pipe manufacturer's written instructions.
- G. Conduit Piping Joints: Assemble sections and finish joints with pourable or split insulation and exterior jacket sleeve, and apply shrink-wrap seals.

3.6 IDENTIFICATION

- A. Install continuous plastic underground warning tapes during backfilling of trenches for underground steam and condensate distribution piping. Locate tapes **6 to 8 inches (150 to 200 mm)** below finished grade, directly over piping. See Section 312000 "Earth Moving" for warning-tape materials and devices and their installation.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections **[with the assistance of a factory-authorized service representative]**.
- D. Tests and Inspections:
 - 1. Prepare steam and condensate piping for testing in accordance with **[ASME B31.9][and][ASME B31.1]** and as follows:
 - a. Leave joints, including welds, uninsulated and exposed for examination during test.
 - b. Isolate equipment and instrumentation. Do not subject equipment and instrumentation to test pressure.
 - c. Install relief valve set to relieve at pressure no more than one-third higher than test pressure.
 - d. Fill system with ambient temperature water. Where there is risk of freezing, perform testing with air or liquid that will not freeze or cause damage to piping system materials.
 - e. For hydrostatic testing, install vents at high points to release trapped air while filling system. Remove test liquid through drip legs installed at accessible low points.
 - 2. Test steam and condensate piping as follows:
 - a. Subject steam and condensate piping to hydrostatic test pressure that is not less than 1.5 times system design pressure. Disconnect connections to equipment and instrumentation during hydrostatic test.
 - b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
 - c. Do not pressurize carrier pipe with air.
 - d. Maintain test pressure for **[two][four]<Insert number>** hours with no loss of pressure.
 - 3. Test conduit as follows:
 - a. Seal vents and drains and subject conduit to **15 psig (105 kPa)** compressed air for four hours with no loss of pressure. Repair leaks and retest.
- E. Piping will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. When successful testing is complete, flush carrier piping to remove dirt or debris remaining after construction. Drain piping after flushing is complete.
- H. Fill underground piping system with permanent system liquid prior to system testing and balancing.

END OF SECTION 23 22 00 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 22 00 00	22 11 16 00d	Steam And Condensate Piping



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 22 16 00 - STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Strainers.
2. Flash tanks.
3. Stop-check valves.
4. Steam safety valves.
5. Steam pressure-reducing valves.
6. Steam traps.
7. Thermostatic air vents and steam vacuum breakers.
8. Flexible connectors.
9. Steam meters.
10. Steam condensate meters.

B. Related Requirements:

1. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.2 ACTION SUBMITTALS

- A. Product Data:** For each type of product.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:** For each type of product.

1.4 QUALITY ASSURANCE

- A. Pipe Welding:** Qualify procedures and operators in accordance with the following:

1. ASME Compliance: Safety valves and pressure vessels to bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Components and installation to be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:**

1. High-Pressure Steam Piping: **<Insert psig (kPa)>**.
2. Low-Pressure Steam Piping: **<Insert psig (kPa)>**.
3. Steam Condensate Piping: **<Insert psig (kPa)>** at **[250 deg F (121 deg C)]<Insert temperature>**.
4. Makeup-Water Piping: **[80 psig (552 kPa)][150 psig (1034 kPa)]<Insert value>** at **[73 deg F (22 deg C)][150 deg F (66 deg C)]<Insert temperature>**.
5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STRAINERS

A. Y-Pattern Strainers, Cast Iron:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Keckley Company]**
 - c. **[Metraflex Company (The)]**
 - d. **[Mueller Steam Specialty; A Watts Water Technologies Company]**
 - e. **[Spirax Sarco Limited]**
 - f. **[Titan Flow Control, Inc.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Keckley Company]**
 - c. **[Metraflex Company (The)]**
 - d. **[Mueller Steam Specialty; A Watts Water Technologies Company]**
 - e. **[Spirax Sarco Limited]**
 - f. **[Titan Flow Control, Inc.]**
 - g. **<Insert manufacturer's name>**
3. Body: ASTM A126, Class B cast iron, with bolted cover and bottom drain connection.
4. End Connections: Threaded ends for strainers **NPS 2 (DN 50)** and smaller; flanged ends for strainers **NPS 2-1/2 (DN 65)** and larger.
5. Strainer Screen: Stainless steel, **[20][40][60]<Insert number>**-mesh strainer or perforated stainless steel basket.
6. Tapped blowoff plug.
7. Rating: **250 psig (1725 kPa)** working steam pressure.

B. Y-Pattern Strainers, Stainless Steel:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Keckley Company]
 - c. [Metraflex Company (The)]
 - d. [Mueller Steam Specialty; A Watts Water Technologies Company]
 - e. [Spirax Sarco Limited]
 - f. [Titan Flow Control, Inc.]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Keckley Company]
 - c. [Metraflex Company (The)]
 - d. [Mueller Steam Specialty; A Watts Water Technologies Company]
 - e. [Spirax Sarco Limited]
 - f. [Titan Flow Control, Inc.]
 - g. <Insert manufacturer's name>
3. Body: ASTM A351/A351M <Insert type> stainless steel, with bolted cover and bottom drain connection.
4. End Connections: [Socket weld][Threaded] for strainers **NPS 2 (DN 50)** and smaller; flanged ends for strainers **NPS 2-1/2 (DN 65)** and larger.
5. Strainer Screen: [1/32 inch (1 mm)][1/16 inch (1.6 mm)]<Insert dimension> perforations in <Insert type> stainless steel strainer screen.
6. Tapped blowoff plug.
7. Rating: [Class 600]<Insert class> for [socket weld][threaded]; [Class 150][Class 300] for flanged.

C. Basket Strainers, Carbon Steel:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Keckley Company]
 - b. [Mueller Steam Specialty; A Watts Water Technologies Company]
 - c. [Titan Flow Control, Inc.]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Keckley Company]
 - b. [Mueller Steam Specialty; A Watts Water Technologies Company]
 - c. [Titan Flow Control, Inc.]
 - d. <Insert manufacturer's name>
3. Body and cover: ASTM A216/A216M Grade WCB carbon steel body and bolted cover; bottom drain connection.
4. End Connections: Threaded ends for strainers **NPS 3 inch (DN 80)** and smaller.



5. Strainer Screen: Stainless steel, [20]<Insert number>-mesh strainer and perforated stainless steel basket with [50]<Insert number> percent free area.
6. Rating: Minimum **150 psig (1034 kPa)** working steam pressure.

D. Basket Strainers, Aluminum Bronze:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Keckley Company]**
 - b. **[Mueller Steam Specialty; A Watts Water Technologies Company]**
 - c. **[Titan Flow Control, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Keckley Company]**
 - b. **[Mueller Steam Specialty; A Watts Water Technologies Company]**
 - c. **[Titan Flow Control, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Body and Cover: ASTM B148, cast aluminum bronze body and bolted cover; bottom drain connection.
4. End Connections: Flanged ends.
5. Strainer Screen: Stainless steel, [20]<Insert number>-mesh strainer and perforated stainless steel basket with [50]<Insert number> percent free area.
6. Rating: Minimum **150 psig (1172 kPa)** working steam pressure

E. Basket Strainers, Cast Iron:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Keckley Company]**
 - b. **[Metraflex Company (The)]**
 - c. **[Mueller Steam Specialty; A Watts Water Technologies Company]**
 - d. **[Spirax Sarco Limited]**
 - e. **[Titan Flow Control, Inc.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Keckley Company]**
 - b. **[Metraflex Company (The)]**
 - c. **[Mueller Steam Specialty; A Watts Water Technologies Company]**
 - d. **[Spirax Sarco Limited]**
 - e. **[Titan Flow Control, Inc.]**

- f. **<Insert manufacturer's name>**
3. Body: ASTM A126, Class B cast iron, with bolted cover and bottom drain connection.
 4. End Connections: Threaded ends for strainers **NPS 2 (DN 50)** and smaller; flanged ends for strainers **NPS 2-1/2 (DN 65)** and larger.
 5. Strainer Screen: Stainless steel, **[20]<Insert number>**-mesh strainer and perforated stainless steel basket with 50 percent free area.
 6. Rating: **250 psig (1725 kPa)** working steam pressure.
- F. Basket Strainers, Stainless Steel:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Keckley Company]**
 - b. **[Metraflex Company (The)]**
 - c. **[Mueller Steam Specialty; A Watts Water Technologies Company]**
 - d. **[Spirax Sarco Limited]**
 - e. **[Titan Flow Control, Inc.]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Keckley Company]**
 - b. **[Metraflex Company (The)]**
 - c. **[Mueller Steam Specialty; A Watts Water Technologies Company]**
 - d. **[Spirax Sarco Limited]**
 - e. **[Titan Flow Control, Inc.]**
 - f. **<Insert manufacturer's name>**
 3. Body: ASTM A351/A351M **<Insert type>** stainless steel, with bolted cover and bottom drain connection.
 4. End Connections: **[Socket weld][Threaded]** for strainers **NPS 2 (DN 50)** and smaller; flanged ends for strainers **NPS 2-1/2 (DN 65)** and larger.
 5. Strainer Screen: **[1/32 inch (1 mm)][1/16 inch (1.6 mm)]<Insert dimension>** perforations in **<Insert type>** stainless steel strainer screen.
 6. Rating: **[Class 600]<Insert class>** for **[socket weld][threaded]**; **[Class 150][Class 300]** for flanged.
- G. Basket Strainers, Fabricated Flanged Ends:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Keckley Company]**
 - b. **[Mueller Steam Specialty; A Watts Water Technologies Company]**
 - c. **[Titan Flow Control, Inc.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Keckley Company]**
 - b. **[Mueller Steam Specialty; A Watts Water Technologies Company]**
 - c. **[Titan Flow Control, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Description: Fabricated, custom engineered, flanged-end basket strainer.
 4. Body Material: **[ASTM A106 Gr. B carbon steel][ASTM A312/A312M Type 304 stainless steel][ASTM A312/A312M Type 316 stainless steel]<Insert body material>**.
 5. Cover Material: **[ASTM A106 Gr. B carbon steel][ASTM A312/A312M Type 316 stainless steel]<Insert cover material>**.
 6. Cover Type: **[Bolted][Quick-open][Davited]<Insert cover type>**.
 7. Inlet/Outlet Flange: **[Slip-on flanged,][Butt-welded flanged,][ASTM A105/A105M carbon steel][ASTM A182/A182M Type 316 stainless steel]**.
 8. Straining Element Material: **[Type 304 stainless steel][Type 316 stainless steel]<Insert straining element material>**
 9. Straining element screen: **[50 mesh]<Insert screen size/configuration>**.
 10. Strainer Open Area: **[50 percent]<Insert percent open area>**.
 11. Drain: **[ASTM A105/A105M carbon steel][ASTM A182/A182M Type 316 stainless steel]<Insert drain material>**.
 12. Vent with Plug: **[ASTM A105/A105M carbon steel][ASTM A182/A182M Type 316 stainless steel]<Insert vent and plug material>**.
 13. Steam Working Pressure: **<Insert minimum steam working pressure>**.
 14. Temperature Rating: **<Insert temperature rating>**.
 15. **<Insert additional features>**.

2.3 FLASH TANKS

- A. Shop or factory fabricated of welded steel in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 for **[150 psig (1035 kPa)]<Insert pressure>** rating and bearing ASME label. Fabricate with tappings for low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.

2.4 Basket Strainers, Aluminum Bronze, Duplex

- A. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Titan Flow Control, Inc.]**
 2. **<Insert manufacturer's name>**

2.5 STOP-CHECK VALVES

- A. Stop-Check Valves - Malleable Iron:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [A.Y. McDonald Mfg. Co.]
 - b. [Crane Fluid Systems; Crane Co.]
 - c. [Jenkins Valves]
 - d. [Lunkenheier Valves; CVC Valves, USA licensed manufacturer.]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [A.Y. McDonald Mfg. Co.]
 - b. [Crane Fluid Systems; Crane Co.]
 - c. [Jenkins Valves]
 - d. [Lunkenheier Valves; CVC Valves, USA licensed manufacturer.]
 - e. <Insert manufacturer's name>
3. Body and Bonnet: Malleable iron.
4. End Connections: Flanged.
5. Disc: Cylindrical with removable liner and machined seat.
6. Stem: Brass alloy.
7. Operator: Outside screw and yoke with cast-iron handwheel.
8. Packing: PTFE-impregnated packing with two-piece packing gland assembly.
9. Pressure Class: 250.

2.6 Basket Strainers, Cast Iron, Duplex

- A. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 1. [Titan Flow Control, Inc.]
 2. <Insert manufacturer's name>

2.7 STEAM SAFETY VALVES

- A. Steam Safety Valves - Bronze or Brass:
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Armstrong International, Inc]
 - c. [Kunkle Valve]
 - d. [Nabic Valves - a division of Crane Co.]
 - e. [Spirax Sarco Limited]
 - f. [WATTS; A Watts Water Technologies Company]
 - g. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]



- b. **[Armstrong International, Inc]**
- c. **[Kunkle Valve]**
- d. **[Nabic Valves - a division of Crane Co.]**
- e. **[Spirax Sarco Limited]**
- f. **[WATTS; A Watts Water Technologies Company]**
- g. **<Insert manufacturer's name>**

- 3. Standard: **[ASME Section I Certified Capacity, National Board V stamp][ASME Section VIII Certified Capacity, National Board UV stamp]**.
- 4. Valve Body Material: **[Bronze][or][brass]**, ASTM B584.
- 5. Disc Material: Forged copper alloy.
- 6. End Connections: Threaded inlet and outlet.
- 7. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
- 8. Pressure Class: 250.
- 9. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet, with threads complying with ASME B1.20.1.
- 10. Size and Capacity: As required for equipment in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

B. Steam Safety Valves - Cast Iron:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Armstrong International, Inc]**
 - c. **[Kunkle Valve]**
 - d. **[Spirax Sarco Limited]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Armstrong International, Inc]**
 - c. **[Kunkle Valve]**
 - d. **[Spirax Sarco Limited]**
 - e. **<Insert manufacturer's name>**
- 3. Standard: **[ASME Section I Certified Capacity, National Board V stamp][ASME Section VIII Certified Capacity, National Board UV stamp]**.
- 4. Valve Body Material: Cast iron, ASTM A126.
- 5. Disc Material: Forged copper alloy with bronze nozzle.
- 6. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
- 7. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
- 8. Pressure Class: 250.
- 9. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
- 10. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.

11. Size and Capacity: As required for equipment in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

2.8 Basket Strainers, Carbon Steel, Duplex

- A. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Titan Flow Control, Inc.]**
2. **<Insert manufacturer's name>**

2.9 STEAM PRESSURE-REDUCING VALVES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Armstrong International, Inc]**
2. **[Cashco, Inc.]**
3. **[Hoffman Specialty; Bell & Gossett, a xylem brand]**
4. **[Leslie Controls, Inc]**
5. **[Spence Engineering Company, Inc]**
6. **[Spirax Sarco Limited]**
7. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Armstrong International, Inc]**
2. **[Cashco, Inc.]**
3. **[Hoffman Specialty; Bell & Gossett, a xylem brand]**
4. **[Leslie Controls, Inc]**
5. **[Spence Engineering Company, Inc]**
6. **[Spirax Sarco Limited]**
7. **<Insert manufacturer's name>**

- C. Capacities and Characteristics:

1. Steam Flow Rate: **<Insert lb/h (kg/s)>**.
2. Inlet Pressure: **<Insert psig (kPa)>**.
3. Outlet Set Pressure: **<Insert psig (kPa)>**.
4. Pressure Loss (Wide Open): **<Insert psig (kPa)>**.

- D. Standard: ASME labeled.

- E. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

- F. Description: Pilot-actuated diaphragm type, with adjustable pressure range and positive shutoff.

- G. Body: **[Cast iron][Stainless steel]**.

- H. End Connections: Threaded connections for valves **NPS 2 (DN 50)** and smaller and flanged connections for valves **NPS 2-1/2 (DN 65)** and larger.



- I. Trim: Hardened stainless steel.
- J. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.
- K. Gaskets: Non-asbestos materials.

2.10 Basket Strainers, Stainless Steel, Duplex

- A. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Titan Flow Control, Inc.]**
 - 2. **<Insert manufacturer's name>**

2.11 STEAM TRAPS

- A. Steam Traps, Thermostatic Type - Bronze:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[Barnes & Jones, Inc]**
 - c. **[Hoffman Specialty; Bell & Gossett, a xylem brand]**
 - d. **[Spirax Sarco Limited]**
 - e. **[Sterling]**
 - f. **[Tunstall Corporation]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[Barnes & Jones, Inc]**
 - c. **[Hoffman Specialty; Bell & Gossett, a xylem brand]**
 - d. **[Spirax Sarco Limited]**
 - e. **[Sterling]**
 - f. **[Tunstall Corporation]**
 - g. **<Insert manufacturer's name>**
 - 3. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
 - 4. Trap Type: Balanced pressure.
 - 5. Bellows: Stainless steel or monel.
 - 6. Head and Seat: Replaceable, hardened stainless steel.
 - 7. Pressure Class: 125.
- B. Steam Traps, Thermostatic Type - Stainless Steel:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Armstrong International, Inc]
 - b. [Spence Engineering Company, Inc]
 - c. [Spirax Sarco Limited]
 - d. [Steriflow; a division of Richards Industrial]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Armstrong International, Inc]
 - b. [Spence Engineering Company, Inc]
 - c. [Spirax Sarco Limited]
 - d. [Steriflow; a division of Richards Industrial]
 - e. <Insert manufacturer's name>
 3. Body: Type 316L or Type 316 stainless steel.
 4. Trap Type: Balanced pressure.
 5. Bellows: Type 316L or Type 316 stainless steel.
 6. Maximum Operating Pressure: At least [100 psig (689 kPa)]<Insert pressure> at saturated steam temperature.
- C. Steam Traps, Thermodynamic Type - Stainless Steel:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Armstrong International, Inc]
 - b. [Barnes & Jones, Inc]
 - c. [Hoffman Specialty; Bell & Gossett, a xylem brand]
 - d. [Spirax Sarco Limited]
 - e. [Tunstall Corporation]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Armstrong International, Inc]
 - b. [Barnes & Jones, Inc]
 - c. [Hoffman Specialty; Bell & Gossett, a xylem brand]
 - d. [Spirax Sarco Limited]
 - e. [Tunstall Corporation]
 - f. <Insert manufacturer's name>
 3. Body: <Insert type> stainless steel with screw-in cap.
 4. End Connections: [Threaded]<Insert connection type>.
 5. Disc and Seat: <Insert type> stainless steel.
 6. Maximum Operating Pressure: [600 psig (4140 kPa)]<Insert pressure>.

D. Steam Traps, Float and Thermostatic Type - Cast Iron:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[Barnes & Jones, Inc]**
 - c. **[Hoffman Specialty; Bell & Gossett, a xylem brand]**
 - d. **[Spirax Sarco Limited]**
 - e. **[Sterling]**
 - f. **[Tunstall Corporation]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[Barnes & Jones, Inc]**
 - c. **[Hoffman Specialty; Bell & Gossett, a xylem brand]**
 - d. **[Spirax Sarco Limited]**
 - e. **[Sterling]**
 - f. **[Tunstall Corporation]**
 - g. **<Insert manufacturer's name>**
3. Body and Bolted Cap: ASTM A126 cast iron.
4. End Connections: Threaded.
5. Float Mechanism: Replaceable, stainless steel.
6. Seat: Hardened stainless steel.
7. Trap Type: Balanced pressure.
8. Thermostatic Bellows: Stainless steel or monel.
9. Thermostatic air vent capable of withstanding **45 deg F (25 deg C)** of superheat and resisting water hammer without sustaining damage.
10. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless steel cage, valve, and seat.
11. Maximum Operating Pressure: **125 psig (860 kPa)**.

E. Steam Traps, Float and Thermostatic Type - Stainless Steel:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[Spirax Sarco Limited]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**

- b. **[Spirax Sarco Limited]**
 - c. **<Insert manufacturer's name>**
- 3. Body and Bolted Cover: **<Insert type>** stainless steel.
 - 4. End Connections: **[Threaded]<Insert end connection type>**.
 - 5. Float Mechanism: **<Insert type>** stainless steel.
 - 6. Seat: **<Insert type>** stainless steel.
 - 7. Strainer: Integral, stainless steel[, **with blowdown valve**].
 - 8. Trap Type: Balanced pressure.
 - 9. Thermostatic air vent.
 - 10. Maximum Operating Pressure: **<Insert pressure>**.
- F. Steam Traps, Inverted Bucket Type - Cast Iron:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Armstrong International, Inc]**
 - b. **[Barnes & Jones, Inc]**
 - c. **[Hoffman Specialty; Bell & Gossett, a xylem brand]**
 - d. **[Spirax Sarco Limited]**
 - e. **[Sterling]**
 - f. **[Tunstall Corporation]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[Barnes & Jones, Inc]**
 - c. **[Hoffman Specialty; Bell & Gossett, a xylem brand]**
 - d. **[Spirax Sarco Limited]**
 - e. **[Sterling]**
 - f. **[Tunstall Corporation]**
 - g. **<Insert manufacturer's name>**
 - 3. Body and Cap: Cast iron.
 - 4. End Connections: Threaded.
 - 5. Head and Seat: Stainless steel.
 - 6. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
 - 7. Bucket: Brass or stainless steel.
 - 8. Strainer: Integral stainless steel inlet strainer within the trap body.
 - 9. Air Vent: Stainless steel thermostatic vent.
 - 10. Pressure Rating: **250 psig (1725 kPa)**.
- G. Steam Traps, Inverted Bucket Type - Stainless Steel:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Armstrong International, Inc]**

- b. [Spence Engineering Company, Inc]
 - c. [Spirax Sarco Limited]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Armstrong International, Inc]
 - b. [Spence Engineering Company, Inc]
 - c. [Spirax Sarco Limited]
 - d. <Insert manufacturer's name>
3. Body and Cap: <Insert type> stainless steel.
4. End Connections: [Threaded]<Insert connection type>.
5. Head and Seat: Stainless steel.
6. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
7. Bucket: Stainless steel.
8. Strainer: Integral stainless steel inlet strainer within the trap body.
9. Air Vent: Stainless steel thermostatic vent.
10. Pressure Rating: Minimum [200 psig at 450 deg F (1379 kPa at 232 deg C)]<Insert pressure at temperature>.

2.12 THERMOSTATIC AIR VENTS AND STEAM VACUUM BREAKERS

A. Air Vents, Thermostatic Type:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Armstrong International, Inc]
 - b. [Barnes & Jones, Inc]
 - c. [Bell & Gossett; a Xylem brand]
 - d. [Hoffman Specialty; Bell & Gossett, a xylem brand]
 - e. [Johnson Corporation (The)]
 - f. [Spirax Sarco Limited]
 - g. [Sterling]
 - h. [Tunstall Corporation]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Armstrong International, Inc]
 - b. [Barnes & Jones, Inc]
 - c. [Bell & Gossett; a Xylem brand]
 - d. [Hoffman Specialty; Bell & Gossett, a xylem brand]
 - e. [Johnson Corporation (The)]
 - f. [Spirax Sarco Limited]
 - g. [Sterling]
 - h. [Tunstall Corporation]

- i. **<Insert manufacturer's name>**
 3. Body: Cast iron, bronze, or stainless steel.
 4. End Connections: Threaded.
 5. Float, Valve, and Seat: Stainless steel.
 6. Thermostatic Element: Phosphor bronze bellows in a stainless steel cage.
 7. Pressure Rating: **[125 psig (861 kPa)][300 psig (2068 kPa)]<Insert value>**.
 8. Maximum Temperature Rating: **[350 deg F (177 deg C)]<Insert temperature>**.
- B. Steam Vacuum Breakers:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Armstrong International, Inc]**
 - b. **[Barnes & Jones, Inc]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Hoffman Specialty; Bell & Gossett, a xylem brand]**
 - e. **[Kadant Johnson LLC]**
 - f. **[Spirax Sarco Limited]**
 - g. **[Tunstall Corporation]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[Barnes & Jones, Inc]**
 - c. **[Bell & Gossett; a Xylem brand]**
 - d. **[Hoffman Specialty; Bell & Gossett, a xylem brand]**
 - e. **[Kadant Johnson LLC]**
 - f. **[Spirax Sarco Limited]**
 - g. **[Tunstall Corporation]**
 - h. **<Insert manufacturer's name>**
 3. Body: Cast iron, bronze, or stainless steel.
 4. End Connections: Threaded.
 5. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
 6. O-Ring Seal: Ethylene propylene rubber.
 7. Pressure Rating: **[125 psig (861 kPa)][300 psig (2068 kPa)]<Insert value>**.
 8. Maximum Temperature Rating: **[350 deg F (177 deg C)]<Insert temperature>**.

2.13 FLEXIBLE CONNECTORS

A. Flexible Connectors, Bellows Type - Stainless Steel:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Duraflex, Inc.]**

- b. [Flexicraft Industries]
 - c. [Hyspan Precision Products, Inc]
 - d. [Mason Industries, Inc.]
 - e. [Metraflex Company (The)]
 - f. [Twin City Hose, Inc.]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. [Duraflex, Inc.]
 - b. [Flexicraft Industries]
 - c. [Hyspan Precision Products, Inc]
 - d. [Mason Industries, Inc.]
 - e. [Metraflex Company (The)]
 - f. [Twin City Hose, Inc.]
 - g. <Insert manufacturer's name>
3. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
4. End Connections: Threaded or flanged to match equipment connected.
5. Performance: Capable of **3/4-inch (20-mm)** misalignment.
6. CWP Rating: **150 psig (1035 kPa)**.
7. Maximum Operating Temperature: **250 deg F (121 deg C)**.

2.14 STEAM METERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1. [Badger Meter, Inc.]
 - 2. [ISTEC Corporation]
 - 3. [Preso Meters; Badger Meter Inc.]
 - 4. [Spirax Sarco Limited]
 - 5. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1. [Badger Meter, Inc.]
 - 2. [ISTEC Corporation]
 - 3. [Preso Meters; Badger Meter Inc.]
 - 4. [Spirax Sarco Limited]
 - 5. <Insert manufacturer's name>
- C. Meters to have a microprocessor to display totalizer flow, flow rate, temperature, pressure, time, and date; alarms for high and low flow rate and temperature.
- 1. Computer to have 4 to 20 mA or 2 to 10 V output for temperature, pressure, and contact closure for flow increments.
 - 2. Independent timers to store four peak flow rates and total flow.
 - 3. Interface compatible with central workstation described in Section 230923 "Direct Digital Control (DDC) System for HVAC."

4. Microprocessor Enclosure: NEMA 250, Type 4.

D. Sensor:

1. Venturi, of **[stainless steel][carbon steel]** construction, for insertion in pipeline between flanges. Sensor has at least 10:1 turndown with plus or minus 1 percent accuracy over full-flow range.
2. Vortex type with stainless steel wetted parts and **[wafer][flange]** connections; and with a piezoelectric sensor removable and serviceable without shutting down the process. Sensor has at least 10:1 turndown with plus or minus 1 percent accuracy over full-flow range.
3. Spring-loaded, variable-area flowmeter type; density compensated with stainless steel wetted parts and **[wafer][flange]** connections. Sensor is to have at least 10:1 turndown with plus or minus 2 percent accuracy over full-flow range.

2.15 STEAM CONDENSATE METERS

A. Steam Condensate Meter - Magnetic Flow Velocity Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Central Station Steam Co.]**
 - b. **[Spirax Sarco Limited]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Central Station Steam Co.]**
 - b. **[Spirax Sarco Limited]**
 - c. **<Insert manufacturer's name>**
3. Flow Element: Magnetic flow velocity type.
 - a. In-line pipe installation utilizing electronically generated magnetic field to measure water velocity.
 - b. Wetted liner: Teflon or ceramic.
 - c. Maximum Fluid Temperature Rating: **[220 deg F (104 deg C)]<Insert temperature>**.
4. Body: **[Manufacturer's standard material]<Insert material>**.
5. Connections: Threaded for **NPS 2 (DN 50)** and smaller; flanged for **NPS 2-1/2 (DN 65)**.
6. Totalizer: Meters to have a microprocessor to display flow, flow rate, time, and date; alarms for high and low flow rate, pressure, and temperature.
 - a. Computer to have 4 to 20 mA or 2 to 10 V output for temperature, pressure, and contact closure for flow increments.
 - b. Independent timers to store four peak flow rates and total flow.
 - c. Interface compatible with central workstation specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - d. Microprocessor Enclosure: NEMA 250, Type 4.
7. Pressure Rating: **[Atmospheric]<Insert pressure>**.
8. Maximum Body Temperature Rating: **[220 deg F (104 deg C)]<Insert temperature>**.

B. Steam Condensate Meter - Gravity Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Central Station Steam Co.]**
 - b. **[Lincoln Meter Company]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Central Station Steam Co.]**
 - b. **[Lincoln Meter Company]**
 - c. **<Insert manufacturer's name>**
3. Flow Element: Gravity type.
 - a. Flow measured by rotating, compartmented drum.
 - b. Casing: Stainless steel.
 - c. Metering drum: Stainless steel.
 - d. Maximum Fluid Temperature Rating: **[220 deg F (104 deg C)]<Insert temperature>**.
4. Body: **[Manufacturer's standard material]<Insert material>**.
5. Connections: Threaded for **NPS 2 (DN 50)** and smaller; flanged for **NPS 2-1/2 (DN 65)**.
6. Totalizer: Meters to have a microprocessor to display flow, flow rate, time, and date; alarms for high and low flow rate, pressure, and temperature.
 - a. Computer to have 4 to 20 mA or 2 to 10 V output for temperature, pressure, and contact closure for flow increments.
 - b. Independent timers to store four peak flow rates and total flow.
 - c. Interface compatible with central workstation specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - d. Microprocessor Enclosure: NEMA 250, Type 4.
7. Pressure Rating: **[Atmospheric]<Insert pressure>**.
8. Maximum Body Temperature Rating: **[220 deg F (104 deg C)]<Insert temperature>**.

PART 3 - EXECUTION

3.1 INSTALLATION OF STRAINERS

- A. Install strainers on inlet side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install **NPS 3/4 (DN 20)** nipple and full-port ball valve in blowdown connection of strainers, **NPS 2 (DN 50)** and larger. Match size of strainer blowoff connection for strainers smaller than **NPS 2 (DN 50)**.

3.2 INSTALLATION OF FLASH TANKS

- A. Pitch steam condensate piping downward no less than **1/4 in./ft. (21 mm/meter)** toward flash tank.
- B. If more than one steam condensate pipe discharges into flash tank, install a check valve in each line.
- C. Install thermostatic air vent at tank top.
- D. Install steam safety valve at tank top.
- E. Install full-port ball valve and swing check valve on condensate outlet.
- F. Install inverted bucket or float and thermostatic trap at low-pressure steam condensate outlet, sized for three times the calculated heat load.
- G. Install pressure gauge on low-pressure steam outlet in accordance with Section 230500 "Common Work Results for HVAC."

3.3 INSTALLATION OF STOP-CHECK VALVES

- A. Install stop-check valves at locations detailed on the Drawings.

3.4 INSTALLATION OF STEAM SAFETY VALVES

- A. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- B. Install safety valves in accordance with **[ASME B31.1.][ASME B31.9.][ASME B31.1 and ASME B31.9.]**
- C. Install safety valve downstream from pressure-reducing valve station as detailed on the Drawings.
- D. Pipe steam safety-valve discharge without valves to atmosphere outside the building.
- E. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.
- F. Install exhaust head with drain to waste, on vents equal to or larger than **NPS 2-1/2 (DN 65)**.

3.5 INSTALLATION OF STEAM PRESSURE-REDUCING VALVES

- A. Install steam pressure-reducing valves in accessible location for maintenance and inspection.
- B. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise detailed on the Drawings.
- C. Install shutoff valves on upstream and downstream sides of pressure-reducing valves or as otherwise detailed on the Drawings.
- D. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections, respectively.

- E. Install pressure gauges on low-pressure side of steam pressure-reducing valves after the bypass connection in accordance with Section 230500 "Common Work Results for HVAC"
- F. Install strainers upstream of steam pressure-reducing valve.

3.6 INSTALLATION OF STEAM TRAPS

- A. Install steam traps in accessible locations as close as possible to connected equipment.
- B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.
- C. Install in accessible locations close to connected equipment.

3.7 INSTALLATION OF THERMOSTATIC AIR VENTS AND STEAM VACUUM BREAKERS

- A. Install air vent and vacuum breakers downstream from control valve, close to coil inlet connection or as otherwise detailed on the Drawings.

3.8 INSTALLATION OF FLEXIBLE CONNECTORS

- A. Install flexible connectors at locations detailed on the Drawings.

3.9 INSTALLATION OF STEAM METERS

- A. Install steam meters with lengths of straight pipe upstream and downstream in accordance with meter manufacturer's written instructions.
- B. See Section 230923 "Direct Digital Control (DDC) System for HVAC" for data acquisition wiring.

3.10 INSTALLATION OF STEAM CONDENSATE METERS

- A. Install steam condensate meters with lengths of straight pipe upstream and downstream in accordance with meter manufacturer's written instructions.
- B. See Section 230923 "Direct Digital Control (DDC) System for HVAC" for data acquisition wiring.

END OF SECTION 23 22 16 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 22 16 00	22 15 13 00	General-Service Compressed-Air Piping
23 22 16 00	22 11 16 00d	Steam And Condensate Piping
23 22 16 00	23 22 00 00	Underground Steam and Condensate Heating Piping
23 22 16 00	23 23 00 00	Refrigerant Piping



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 22 23 00 - STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-stage, centrifugal steam condensate pumps with floor-mounted receiver.
2. Multistage, centrifugal steam condensate pumps with elevated receiver.
3. Single-stage, centrifugal steam condensate pumps with elevated receiver.
4. Vertical, wet-pit-mounted steam condensate pumps.
5. Pressure-powered steam condensate pumps.

1.2 DEFINITIONS

- A. PPE:** Polyphenylene ether.
- B. PPO:** Polyphenylene oxide.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of steam condensate pump.
 - a. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, and accessories.
 - b. Indicate pump's operating point on curves.
 - c. Include receiver capacity and material.

B. Shop Drawings: For each pump/receiver.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates for steam condensate pumps/receivers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps.
 - 1. Indicate actual installed items by marking submittals with an arrow or box.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of pump from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."
- D. Seismic Performance: Steam condensate pumps/receivers to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]**."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.3 SINGLE-STAGE, CENTRIFUGAL STEAM CONDENSATE PUMPS WITH FLOOR-MOUNTED RECEIVER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Armstrong International, Inc]**
 - 2. **[ITT Corporation]**
 - 3. **[Roth Pump Company]**
 - 4. **[Skidmore Pump]**
 - 5. **[Spirax Sarco Limited]**
 - 6. **[Sterling]**
 - 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Armstrong International, Inc]**
 2. **[ITT Corporation]**
 3. **[Roth Pump Company]**
 4. **[Skidmore Pump]**
 5. **[Spirax Sarco Limited]**
 6. **[Sterling]**
 7. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated, packaged, **[simplex][duplex]<Insert number of pumps>**, electric-driven pumps; with receiver, float switch(es), **[control panel and controls,]** and accessories suitable for operation with steam condensate up to **200 deg F (93 deg C)**.
- D. Receiver:
1. Floor mounted.
 2. Material: **[Cast iron][Carbon steel][Stainless steel]**.
 3. Externally adjustable float switch for each pump.
 4. Flanges for pump mounting.
 5. Water-level gauge and dial thermometer.
 6. Pressure gauge at each pump discharge.
 7. Isolation valve between pump and receiver.
 8. Lifting eyebolts.
 9. Vent and overflow.
 10. Inlet strainer with vertical self-cleaning bronze screen and large dirt pocket.
- E. Pumps:
1. Centrifugal, close-coupled, vertical design.
 2. Permanently aligned.
 3. Impeller: **[Bronze][stainless steel][or][modified PPO/PPE blend thermoplastic]**.
 4. Mechanical seals rated at **250 deg F (120 deg C)**.
 5. Mounted on receiver flange.
- F. Motor:
1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 2. Enclosure: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 3. Enclosure Materials: Cast iron, cast aluminum, or rolled steel.
 4. Motor Bearings: **[Permanently lubricated][Grease-lubricated]** ball bearings.
 5. Service Conditions:
 - a. Ambient Temperature: **<Insert deg C>**.
 - b. Altitude: **<Insert feet (meters)>** above sea level.
 - c. High Humidity: **<Insert wet bulb deg F (deg C)>**.
 - d. **<Insert conditions>**.
 6. Efficiency: Premium efficient.
 7. NEMA Design: **<Insert designation>**.
 8. Service Factor: **<Insert value>**.
- G. Control Panel:
1. NEMA 250, **[Type 1][Type 12]<Insert type>** enclosure with hinged door and grounding lug, mounted on receiver.
 2. Combination magnetic starter with fused disconnect **[for each pump,]** and cover interlock.

3. Factory wired between pump(s) and float switches, for single external electrical connection.
4. Provide fused, control-power transformer if panel exceeds 120 V ac.
5. Automatic electrical pump alternator to operate pumps in **[lead-lag]<Insert sequence>** sequence and allow **[both][all]** pumps to operate upon receiver high-level signal.
6. Manual control to override electrical pump alternator and manually select the lead pump.
7. Hand-off-auto selector switch for each pump.
8. Momentary-contact "TEST" push-button on cover for each pump.
9. All power and control wiring prewired for single external electrical connection.
10. Numbered terminal strip.
11. Disconnect switch.

H. Capacities and Characteristics:

1. Number of Pumps: **<Insert number>**.
2. Capacity, Each Pump:
 - a. Flow: **<Insert gpm (L/s)>**.
 - b. Discharge Head: **<Insert psig (kPa)>**.
 - c. Discharge Size: **<Insert NPS (DN)>**.
 - d. Speed: **<Insert rpm>**.
 - e. Motor Horsepower: **<Insert value>**.
3. Receiver:
 - a. Capacity: **<Insert gal. (L)>**.
 - b. Inlet Size: **<Insert NPS (DN)>**.
 - c. Height to Inlet: **<Insert inches (mm)>**.
4. Electrical Characteristics:
 - a. Volts: **[120][230][240]<Insert value>**.
 - b. Phase: Single.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value> A.**
 - e. Minimum Circuit Ampacity: **<Insert value> A.**
 - f. Maximum Overcurrent Protection: **<Insert value> A.**

2.4 MULTISTAGE CENTRIFUGAL STEAM CONDENSATE PUMPS WITH ELEVATED RECEIVER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Skidmore Pump]**
 2. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Skidmore Pump]**
 2. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated, packaged, **[simplex][duplex][triplex][quadraplex]**, electric-driven pumps; with receiver, pumps, float switch(es), **[control panel and controls,]** and accessories suitable

for operation with steam condensate up to **200 deg F (93 deg C)**.

D. Receiver:

1. Elevated, mounted on fabricated-steel supports.
2. Material: Carbon steel.
3. Externally adjustable float switch for each pump.
4. Water-level gauge and dial thermometer.
5. Pressure gauge at each pump discharge.
6. Isolation valves between pump and receiver.
7. Lifting eyebolts.
8. Vent and overflow connections.
9. Inlet cascade baffle and convex heads.
10. Inlet strainer with self-cleaning bronze screen, dirt pocket, and cleanout plug on receiver inlet.

E. Pumps:

1. Centrifugal, **[two-stage][multistage]**, close coupled.
2. Vertical design, permanently aligned.
3. Impeller: **[Bronze][Type 304 stainless steel][Type 316 stainless steel]**.
4. Stainless steel shafts.
5. Mechanical seals rated at **250 deg F (120 deg C)**.
6. Mounted on base below the receiver.
7. Rated to operate with a minimum of **2 ft. (610 mm)** of NPSH.

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
2. Enclosure: **[Open, dripproof][Totally enclosed fan cooled]<Insert type>**.
3. Enclosure Materials: Cast iron, cast aluminum, or rolled steel.
4. Motor Bearings: **[Permanently lubricated][Grease-lubricated]** ball bearings.
5. Service Conditions:
 - a. Ambient Temperature: **<Insert deg C>**.
 - b. Altitude: **<Insert feet (meters)>** above sea level.
 - c. High Humidity: **<Insert wet bulb deg F (deg C)>**.
 - d. **<Insert conditions>**.
6. Efficiency: Premium efficient.
7. NEMA Design: **<Insert designation>**.
8. Service Factor: **<Insert value>**.

G. Pipe: **[ASTM A53/A53M, Type S, Grade B][ASTM A106/A106M; Schedule 80; seamless steel]**.

H. Fittings NPS 2 (DN 50) and Smaller: ASME B16.1, Class 125 **[cast iron][stainless steel]**, threaded.

I. Fittings NPS 2-1/2 (DN 65) and Larger: ASTM A234/A234M, steel, for welded connections.

J. Control Panel:

1. NEMA 250, **[Type 1][Type 12]<Insert type>** enclosure with hinged door and grounding lug, mounted on receiver.
2. Combination magnetic starter with fused disconnect **[for each pump,]** and cover interlock.
3. Factory wired between pumps and float switches, for single external electrical connection.
4. Provide fused, control-power transformer if panel exceeds 120 V ac.

5. Automatic electrical pump alternator to operate pumps in [lead-lag]<Insert sequence> sequence and allow [both][all] pumps to operate upon receiver high-level signal.
6. Manual control to override electrical pump alternator and manually select the lead pump.
7. Hand-off-auto selector switch for each pump.
8. Momentary-contact "TEST" push-button on cover for each pump.
9. All power and control wiring prewired for single external electrical connection.
10. Numbered terminal strip.
11. Disconnect switch.

K. Capacities and Characteristics:

1. Number of Pumps: <Insert number>.
2. Capacity, Each Pump:
 - a. Flow: <Insert gpm (L/s)>.
 - b. Discharge Head: <Insert psig (kPa)>.
 - c. Discharge Size: <Insert NPS (DN)>.
 - d. Speed: <Insert rpm>.
 - e. Motor Horsepower: <Insert value>.
3. Receiver:
 - a. Capacity: <Insert gal. (L)>.
 - b. Inlet Size: <Insert NPS (DN)>.
 - c. Height to Inlet: <Insert inches (mm)>.
4. Electrical Characteristics:
 - a. Volts: [120][208][230][240][480]<Insert value>.
 - b. Phase: [Single][Three].
 - c. Hertz: 60.
 - d. Full-Load Amperes: <Insert value> A.
 - e. Minimum Circuit Ampacity: <Insert value> A.
 - f. Maximum Overcurrent Protection: <Insert value> A.

2.5 SINGLE-STAGE, CENTRIFUGAL STEAM CONDENSATE PUMPS WITH ELEVATED RECEIVER

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [ITT Corporation]
2. [Skidmore Pump]
3. [Spirax Sarco Limited]
4. [Sterling]
5. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [ITT Corporation]
2. [Skidmore Pump]
3. [Spirax Sarco Limited]
4. [Sterling]

5. <Insert manufacturer's name>
- C. Description: Factory-fabricated, packaged, [simplex][duplex]<Insert number of pumps>, electric-driven pumps; with elevated receiver, pumps, float switch(es), controls, [control panel,] and accessories suitable for operation with steam condensate up to **200 deg F (93 deg C)**.
- D. Receiver:
 1. Elevated, mounted on fabricated-steel supports.
 2. Material: **[Cast iron][Welded steel][Stainless steel]**.
 3. Externally adjustable float switch for each pump.
 4. Water-level gauge and dial thermometer.
 5. Pressure gauge at each pump discharge.
 6. Isolation valves between receiver and pumps.
 7. Lifting eyebolts.
 8. Vent and overflow connections.
 9. Inlet cascade baffle and convex heads.
 10. Inlet strainer with self-cleaning bronze screen, dirt pocket, and cleanout plug on receiver inlet.
- E. Pumps:
 1. Centrifugal, close coupled.
 2. Permanently aligned.
 3. Impeller: **[Bronze][stainless steel][or][modified PPO/PPE blend thermoplastic]**.
 4. Stainless steel shafts.
 5. Mechanical seals rated at **250 deg F (120 deg C)**.
 6. Mounted on base below the receiver.
 7. Rated to operate with a minimum of **2 ft. (610 mm)** of NPSH.
- F. Motor:
 1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 2. Enclosure: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 3. Enclosure Materials: **[Cast iron][Cast aluminum][Rolled steel]**.
 4. Motor Bearings: **[Permanently lubricated][Grease-lubricated]** ball bearings.
 5. Service Conditions:
 - a. Ambient Temperature: **<Insert deg C>**.
 - b. Altitude: **<Insert feet (meters)>** above sea level.
 - c. High Humidity: **<Insert wet bulb deg F (deg C)>**.
 - d. **<Insert conditions>**.
 6. Efficiency: Premium efficient.
 7. NEMA Design: **<Insert designation>**.
 8. Service Factor: **<Insert value>**.
- G. Pipe: **[ASTM A53/A53M, Type S, Grade B][ASTM A106/A106M; Schedule 80; seamless steel]**.
- H. Fittings NPS 2 (DN 50) and Smaller: ASME B16.1, Class 125 **[cast iron][stainless steel]**, threaded.
- I. Fittings NPS 2-1/2 (DN 65) and Larger: ASTM A234/A234M, steel, for welded connections.
- J. Control Panel:
 1. NEMA 250, **[Type 1][Type 12]<Insert type>** enclosure with hinged door and grounding lug,

- mounted on pump.
2. Combination magnetic starter with fused disconnect[**for each pump,**] and cover interlock.
3. Factory wired between pumps and float switches, for single external electrical connection.
4. Provide fused, control-power transformer if panel exceeds 120 V ac.
5. Automatic electrical pump alternator to operate pumps in [**lead-lag**]**<Insert sequence>** sequence and allow [**both**]**[all]** pumps to operate upon receiver high-level signal.
6. Manual control to override electrical pump alternator and manually select the lead pump.
7. Hand-off-auto selector switch for each pump.
8. Momentary-contact "TEST" push-button on cover for each pump.
9. All power and control wiring prewired for single external electrical connection.
10. Numbered terminal strip.
11. Disconnect switch.

K. Capacities and Characteristics:

1. Number of Pumps: **<Insert number>**.
2. Capacity, Each Pump:
 - a. Flow: **<Insert gpm (L/s)>**
 - b. Discharge Head: **<Insert psig (kPa)>**.
 - c. Discharge Size: **<Insert NPS (DN)>**.
 - d. Speed: **<Insert rpm>**.
 - e. Motor Horsepower: **<Insert value>**.
3. Receiver:
 - a. Capacity: **<Insert gal. (L)>**.
 - b. Inlet Size: **<Insert NPS (DN)>**.
 - c. Height to Inlet: **<Insert inches (mm)>**.
4. Electrical Characteristics:
 - a. Volts: [**120**]**[208]****[230]****[240]****[480]****<Insert value>**.
 - b. Phase: [**Single**]**[Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>** A.
 - e. Minimum Circuit Ampacity: **<Insert value>** A.
 - f. Maximum Overcurrent Protection: **<Insert value>** A.

2.6 VERTICAL, WET-PIT-MOUNTED STEAM CONDENSATE PUMPS

- A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**]**[provide products by one of the following]****[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[ITT Corporation]**
 2. **[Roth Pump Company]**
 3. **[Skidmore Pump]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[ITT Corporation]**

2. **[Roth Pump Company]**
 3. **[Skidmore Pump]**
 4. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated, packaged, **[simplex][duplex]**, electric-driven pumps; with float switch(es), **[control panel and controls,]** and accessories suitable for operation with steam condensate up to **200 deg F (93 deg C)**.
- D. Basin: Cast iron, with hub-type inlets.
1. Cast-iron inlet strainer with vertical self-cleaning bronze screen and large dirt pocket.
 2. Discharge pressure gauges.
 3. Float switch(es): One float switch for each pump or a single float with operating contacts for each pump.
 4. Anchor Flange: Cast iron, attached to basin, in location and of size required to anchor basin to concrete slab.
- E. Basin Cover: Cast-iron or steel cover for each pump with gasketed openings for access to pumps, pump shafts, control rods, discharge piping, and vent connections.
- F. Pumps:
1. Vertical, wet-pit mounted, flexible coupled, and suspended.
 2. Cast-iron casing with open inlet.
 3. Stainless steel shaft with oil-lubricated, bronze, intermediate sleeve bearings; **48-inch (1200-mm)** maximum intervals where basin depth is more than **48 inches (1200 mm)**; and grease-lubricated, ball-type, thrust bearings.
 4. Shaft Couplings: Flexible, capable of absorbing vibration.
 5. Impeller: **[Bronze][Stainless steel]**.
 6. Mechanical seals rated at **250 deg F (120 deg C)**, with carbon rotating ring bearing on a ceramic seat held by a stainless steel spring and enclosed by a flexible bellows and gasket.
- G. Motors:
1. Vertically mounted on cast-iron pedestal.
 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 3. Enclosure: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 4. Enclosure Materials: Cast iron, cast aluminum, or rolled steel.
 5. Motor Bearings: **[Permanently lubricated][Grease-lubricated]** ball bearings.
 6. Service Conditions:
 - a. Ambient Temperature: **<Insert deg C>**.
 - b. Altitude: **<Insert feet (meters)>** above sea level.
 - c. High Humidity: **<Insert wet bulb deg F (deg C)>**.
 - d. **<Insert conditions>**.
 7. Efficiency: Premium efficient.
 8. NEMA Design: **<Insert designation>**.
 9. Service Factor: **<Insert value>**.
- H. Pump Discharge Piping: Manufacturer's standard steel or bronze pipe unless otherwise indicated.
- I. Control Panel:
1. NEMA 250, **[Type 1][Type 12]<Insert type>** enclosure with hinged door and grounding lug,

- mounted on pump.
- 2. Combination magnetic starter with fused disconnect for each pump and cover interlock.
- 3. Factory wired between pumps and float switches, for single external electrical connection.
- 4. Provide fused, control-power transformer if panel exceeds 120 V ac.
- 5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate upon receiver high-level signal.
- 6. Manual control to override electrical pump alternator and manually select the lead pump.
- 7. Hand-off-auto selector switch for each pump.
- 8. Momentary-contact "TEST" push-button on cover for each pump.
- 9. Numbered terminal strip.
- 10. Disconnect switch.

J. Capacities and Characteristics:

- 1. Capacity, Each of Two Pumps:
 - a. Flow: **<Insert gpm (L/s)>**.
 - b. Discharge Head: **<Insert psig (kPa)>**.
 - c. Discharge Size: **<Insert NPS (DN)>**.
 - d. Speed: **<Insert rpm>**.
 - e. Motor Horsepower: **<Insert value>**.
- 2. Underground Basin:
 - a. Diameter: **<Insert inches (mm)>**.
 - b. Depth: **<Insert inches (mm)>**.
 - c. Inlet Size: **<Insert NPS (DN)>**.
 - d. Bottom to Centerline of Inlet: **<Insert inches (mm)>**.
- 3. Electrical Characteristics:
 - a. Volts: **[120][208][230][480]<Insert value>**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value> A**.
 - e. Minimum Circuit Ampacity: **<Insert value> A**.
 - f. Maximum Overcurrent Protection: **<Insert value> A**.

2.7 PRESSURE-POWERED STEAM CONDENSATE PUMPS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1. **[Armstrong International, Inc]**
- 2. **[Cemline Corporation]**
- 3. **[Kadant Johnson LLC]**
- 4. **[Spence Engineering Company, Inc]**
- 5. **[Spirax Sarco Limited]**
- 6. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [Armstrong International, Inc]
 2. [Cemline Corporation]
 3. [Kadant Johnson LLC]
 4. [Spence Engineering Company, Inc]
 5. [Spirax Sarco Limited]
 6. <Insert manufacturer's name>
- C. Description: Factory-fabricated, [simplex][duplex], pressure-powered pumps with float-operated valve controls, valves, piping connections, and accessories suitable for pumping steam condensate using [steam][compressed air].
- D. Pump Body: [Cast iron][Welded steel], ASME rated to **125 psig (860 kPa)**.
- E. Piping Connections: Threaded or flanged; for steam condensate inlet, outlet, operating medium, vent, and indicated accessories.
- F. Level Gauge: Glass site gauge with shutoff cocks.
- G. Valves: Manufacturer's standard check valves on inlet and outlet.
- H. Internal Parts: Stainless steel float, springs, and actuating mechanism.
- I. Valve Seals: Replaceable from exterior.
- J. Receiver:
1. Factory skid-mounted on steel supports.
 2. Material; [Cast iron][Welded steel][Type 316 stainless steel].
 3. Threaded or flanged piping connections.
 4. Water-level gauge and dial thermometer.
 5. Pressure gauge at pump discharge.
 6. Bronze fitting isolation valve between pump and receiver.
 7. Lifting eyebolts.
 8. Inlet vent and an overflow.
 9. Cast-iron inlet strainer with vertical self-cleaning bronze screen and large dirt pocket.
- K. Pipe: ASTM A53/A53M, Type S, Grade B or ASTM A106/A106M; Schedule 80; seamless steel.
- L. Fittings: Wrought steel, ASTM A234/A234M with wall thickness to match adjacent pipe or wrought cast-and forged-steel flanges and flanged fittings, ASME B16.5.
- M. Capacities and Characteristics:
1. Number of Pumps: <Insert number>.
 2. Capacity, Each Pump:
 - a. Flow: <Insert gpm (L/s)>.
 - b. Discharge Head: <Insert psig (kPa)>.
 - c. Discharge Size: <Insert NPS (DN)>.
 3. Operating Steam Pressure: <Insert psig (kPa)>.
 4. Steam Consumption Rate: <Insert lb/1000 lb (kg/1000 kg)> of steam condensate.
 5. Operating Compressed-Air Pressure: <Insert psig (kPa)>.
 6. Compressed-Air Consumption Rate: <Insert cu. ft./1000 lb (L/1000 kg)> of steam condensate.
 7. Receiver:

- a. Capacity: <Insert gal. (L)>.
- b. Inlet Size: <Insert NPS (DN)>.
- c. Height to Inlet: <Insert inches (mm)>.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF STEAM CONDENSATE PUMPS

- A. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.
- B. Support pumps and piping separately so piping is not supported by pumps.
- C. Install thermometers and pressure gauges.
- D. Equipment Mounting:
 - 1. Install pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
- B. Where installing piping adjacent to machine, allow space for service and maintenance.
- C. Install compressed-air supply for pressure-powered pumps as required in Section 221513 "General-Service Compressed-Air Piping."
- D. Install a globe and check valve at inlet of each pump and a gate and check valve at pump outlet.
- E. Install pressure gauge at each pump discharge.
- F. Pipe drain to nearest floor drain for overflow and drain piping connections.

- G. Install full-size vent piping to outdoors, terminating in 180-degree elbow.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. For units with single-phase motors and without control panel, wire float switch in series with each motor.
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 SYSTEM STARTUP

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Clean strainers.
 3. Adjust steam condensate pump controls.
 4. Adjust pump controls for automatic start, stop, and alarm operation.
 5. Perform the following operational checks before starting:
 - a. Set float switches to operate at proper levels.
 - b. Check motors for proper rotation.
 - c. Test pump controls and demonstrate compliance with requirements.
 - d. Replace damaged or malfunctioning pump controls and equipment.
 - e. Verify that pump controls are correct for required application.
 6. Start steam condensate pumps in accordance with manufacturer's written startup instructions.

3.7 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain steam condensate pumps.

END OF SECTION 23 22 23 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 22 23 00	22 11 16 00d	Steam And Condensate Piping
23 22 23 00	23 22 00 00	Underground Steam and Condensate Heating Piping
23 22 23 13	22 11 16 00d	Steam And Condensate Piping
23 22 23 13	23 22 00 00	Underground Steam and Condensate Heating Piping
23 22 23 13	23 22 23 00	Steam Condensate Pumps



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 23 00 00 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Valves and specialties.
4. Refrigerants.

1.2 ACTION SUBMITTALS

A. Product Data: For each specified system and assembly, including components and accessories.

1. Submit data for each type of refrigerant piping, fitting, valve, piping specialty, and refrigerant.

B. Shop Drawings:

1. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, at a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
2. Show interface and spatial relationships between piping and equipment.
3. Shop Drawing Scale: [1/4 inch equals 1 ft. (1:50)]<Insert value> .

C. Delegated Design Submittals: For refrigerant piping design, including sizing and layout, oil traps, double risers, specialties, and pipe and tube sizes to accommodate, at a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

D. Sustainable Design Submittals:

1. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
2. Product Data: For refrigerants, indicating compliance with refrigerant management practices.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Provide plans, piping schematics, and details, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Welding Certificates: For each welder performing shop or field welding on Project.

C. Field Quality Control Reports: For each specified field quality-control test and inspection.

D. Delegated Design Engineer Qualification Statement: For refrigerant piping design.



1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with ASME Boiler and Pressure Vessel Code: Section IX, "Welding, Brazing, and Fusing Qualifications."
- B. Delegated Design Engineer Qualifications: A professional engineer who is legally qualified to practice in [state]<Insert jurisdiction> where Project is located and who is experienced in providing engineering services of the type indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.
- B. Prepare valves and specialties for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads and other end connections.
- C. Use precautions during storage as follows:
 - 1. Maintain valve and specialty end protection.
 - 2. Store valves and specialties indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," for refrigerant piping size and layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
- B. Comply with ASHRAE 15 and ASHRAE 34.
- C. Comply with ASME B31.5.
- D. Test Pressure for Refrigerant R-32:
 - 1. Suction Tubing for Refrigeration and Air-Conditioning Applications Other than Heat Pumps: [300 psig (2068 kPa)]<Insert pressure> .
 - 2. Suction Tubing for Heat-Pump Applications: [535 psig (3689 kPa)]<Insert pressure> .
 - 3. Hot-Gas and Liquid Tubing: [535 psig (3689 kPa)]<Insert pressure> .
- E. Test Pressure for Refrigerant R-454B:

1. Suction Tubing for Refrigeration and Air-Conditioning Applications Other than Heat Pumps: **[300 psig (2068 kPa)]<Insert pressure>** .
2. Suction Tubing for Heat-Pump Applications: **[535 psig (3689 kPa)]<Insert pressure>** .
3. Hot-Gas and Liquid Tubing: **[535 psig (3689 kPa)]<Insert pressure>** .

2.2 COPPER TUBE AND FITTINGS

- A. Copper Tube, for Refrigerant Piping: **[ASTM B280, Type ACR,][drawn-temper][and][annealed-temper]<Insert ASTM standard and type>** .
- B. Wrought-Copper Fittings, Brazed Joint: ASME B16.50.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Brazing Filler Metals: AWS A5.8M/A5.8.
- E. Flexible Connectors:
 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 2. End Connections: Socket ends.
 3. Offset Performance: Capable of minimum **3/4-inch (20-mm)** misalignment in minimum **7-inch- (180-mm-)** long assembly.
 4. Working Pressure Rating: Factory test at minimum **[500 psig (3450 kPa)]<Insert pressure rating>** .
 5. Maximum Operating Temperature: **[250 deg F (121 deg C)]<Insert temperature>** .
- F. Copper-Tube, Pressure-Seal-Joint Fittings for Refrigerant Piping:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Conex Bänninger; a part of IBP Group LLC]**
 - b. **[Mueller Streamline Co.; a company of Mueller Industries]**
 - c. **[Parker Hannifin; Sporlan Division]**
 - d. **[RLS LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Conex Bänninger; a part of IBP Group LLC]**
 - b. **[Mueller Streamline Co.; a company of Mueller Industries]**
 - c. **[Parker Hannifin; Sporlan Division]**
 - d. **[RLS LLC]**
 - e. **<Insert manufacturer's name>**
 3. Standard: UL 207; certified by UL for field installation. Certification as a UL-recognized component alone is unacceptable.
 4. Housing: Copper.
 5. O-Rings: **[HNBR]<Insert material type>** compatible with specific refrigerant.
 6. Tools: Manufacturer's approved special tools.
 7. Minimum Rated Pressure: **[700 psig (48 bar)]<Insert pressure>** .



2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M, black steel with plain ends; type, grade, and pipe schedule as selected in "Piping Application Schedules" Article.
- B. Wrought-Steel Fittings: ASTM A234/A234M, for welded joints.
- C. Steel Flanges and Flanged Fittings: ASME B16.5 steel, including bolts, nuts, gaskets, bevel-welded end connection, and raised face.
- D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 and ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- E. Flanged Unions:
 - 1. Body: Forged-steel flanges for **NPS 1 to NPS 1-1/2 (DN 25 to DN 40)** and ductile iron for **NPS 2 to NPS 3 (DN 50 to DN 80)**. Factory apply rust-resistant finish.
 - 2. Gasket: Fiber asbestos free.
 - 3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Factory apply rust-resistant finish.
 - 4. Offset Performance: Capable of minimum **3/4-inch (20-mm)** misalignment in minimum **7-inch-(180-mm-)** long assembly.
 - 5. Pressure Rating: Factory test at minimum **[400 psig (2760 kPa)]<Insert pressure>** .
 - 6. Maximum Operating Temperature: **330 deg F (165 deg C)**.
- F. Flexible Connectors:
 - 1. Body: Stainless steel bellows with woven, flexible, stainless steel-wire-reinforced protective jacket.
 - 2. End Connections:
 - a. NPS 2 (DN 50) and Smaller: With threaded-end connections.
 - b. NPS 2-1/2 (DN 65) and Larger: With flanged-end connections.
 - 3. Offset Performance: Capable of minimum **3/4-inch (20-mm)** misalignment in minimum **7-inch-(180-mm-)** long assembly.
 - 4. Pressure Rating: Factory test at minimum **[500 psig (3450 kPa)]<Insert pressure>** .
 - 5. Maximum Operating Temperature: **[250 deg F (121 deg C)]<Insert temperature>** .

2.4 Copper-Tube, Solder Fittings for Refrigerant

- A. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **<Insert manufacturer's name>**

2.5 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following] :

- a. [Danfoss, Inc.]
 - b. [Henry Technologies Inc.; The Henry Group]
 - c. [Parker (Parker Hannifin)]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Danfoss, Inc.]
 - b. [Henry Technologies Inc.; The Henry Group]
 - c. [Parker (Parker Hannifin)]
 - d. <Insert manufacturer's name>
3. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
4. Diaphragm: Phosphor bronze and stainless steel with stainless steel spring.
5. Operator: Rising stem and hand wheel.
6. Seat: Nylon.
7. End Connections: Socket, union, or flanged.
8. Working Pressure Rating: [500 psig (3450 kPa)]<Insert pressure> .
9. Maximum Operating Temperature: [240 deg F (116 deg C)]<Insert temperature> .

B. Packed-Angle Valves:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
- a. [Danfoss, Inc.]
 - b. [Henry Technologies Inc.; The Henry Group]
 - c. [Parker (Parker Hannifin)]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Danfoss, Inc.]
 - b. [Henry Technologies Inc.; The Henry Group]
 - c. [Parker (Parker Hannifin)]
 - d. <Insert manufacturer's name>
3. Body and Bonnet: Forged brass or cast bronze.
4. Packing: Molded stem, back seating, and replaceable under pressure.
5. Operator: Rising stem.
6. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
7. Seal Cap: Forged-brass or valox hex cap.
8. End Connections: Socket, union, threaded, or flanged.
9. Working Pressure Rating: [500 psig (3450 kPa)]<Insert pressure> .
10. Maximum Operating Temperature: [275 deg F (135 deg C)]<Insert temperature> .

C. Check Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Danfoss, Inc.]**
 - c. **[Henry Technologies Inc.; The Henry Group]**
 - d. **[Parker (Parker Hannifin)]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Danfoss, Inc.]**
 - c. **[Henry Technologies Inc.; The Henry Group]**
 - d. **[Parker (Parker Hannifin)]**
 - e. **<Insert manufacturer's name>**
3. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
4. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
5. Piston: Removable polytetrafluoroethylene seat.
6. Closing Spring: Stainless steel.
7. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
8. End Connections: Socket, union, threaded, or flanged.
9. Maximum Opening Pressure: **0.50 psig (3.4 kPa)**.
10. Working Pressure Rating: **[500 psig (3450 kPa)]<Insert pressure>** .
11. Maximum Operating Temperature: **[275 deg F (135 deg C)]<Insert temperature>** .

D. Service Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[JB Industries]**
 - d. **[Parker (Parker Hannifin)]**
 - e. **[RectorSeal HVAC; a CSW Industrials Company]**
 - f. **[Refrigeration Sales, Inc.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[JB Industries]**
 - d. **[Parker (Parker Hannifin)]**
 - e. **[RectorSeal HVAC; a CSW Industrials Company]**

- f. **[Refrigeration Sales, Inc.]**
 - g. **<Insert manufacturer's name>**
- 3. Body: Forged brass with brass cap, including key end to remove core.
 - 4. Core: Removable ball-type check valve with stainless steel spring.
 - 5. Seat: Polytetrafluoroethylene.
 - 6. End Connections: Copper spring.
 - 7. Working Pressure Rating: **[500 psig (3450 kPa)]<Insert pressure>** .
 - 8. Maximum Operating Temperature: **[275 deg F (135 deg C)]<Insert temperature>** .
- E. Refrigerant Locking Caps:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[C & D Valve, LLC]**
 - b. **[JB Industries]**
 - c. **[RectorSeal HVAC; a CSW Industrials Company]**
 - d. **[Refrigeration Sales, Inc.]**
 - e. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[C & D Valve, LLC]**
 - b. **[JB Industries]**
 - c. **[RectorSeal HVAC; a CSW Industrials Company]**
 - d. **[Refrigeration Sales, Inc.]**
 - e. **<Insert manufacturer's name>**
 - 3. Description: Locking-type, tamper-resistant, threaded caps to protect refrigerant-charging ports from unauthorized refrigerant access and leakage.
 - 4. Material: Brass, with protective shroud or sleeve.
 - 5. Refrigerant Identification: **[Color-coded, refrigerant specific based on AHRI Guideline N][or][Universal]** design.
 - 6. Special Tool: For installing and unlocking.
- F. Solenoid Valves: Comply with **AHRI 760 I-P (AHRI 761 SI)** and UL 429; listed and labeled by an NRTL.
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
 3. Body and Bonnet: Plated steel.
 4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 5. Seat: Polytetrafluoroethylene.
 6. End Connections: Threaded.
 7. Electrical: Molded, watertight coil in ANSI/NEMA 250 enclosure of type required by location with **1/2-inch (16-mm)** conduit adapter, and **[24][115][208]** V ac coil.
 8. Working Pressure Rating: **[400 psig (2760 kPa)]<Insert pressure>** .
 9. Maximum Operating Temperature: **[240 deg F (116 deg C)]<Insert temperature>** .
- G. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
 3. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 4. Piston, Closing Spring, and Seat Insert: Stainless steel.
 5. Seat: Polytetrafluoroethylene.
 6. End Connections: Threaded.
 7. Working Pressure Rating: **[400 psig (2760 kPa)]<Insert pressure>** .
 8. Maximum Operating Temperature: **[240 deg F (116 deg C)]<Insert temperature>** .
- H. Thermostatic Expansion Valves: Comply with **AHRI 750 I-P (AHRI 751 SI)**.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker Hannifin; Sporlan Division]**
 - d. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker Hannifin; Sporlan Division]**
 - d. **<Insert manufacturer's name>**
 3. Body, Bonnet, and Seal Cap: Forged brass or steel.
 4. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 5. Packing and Gaskets: Non-asbestos.
 6. Capillary and Bulb: Copper tubing filled with refrigerant charge.
 7. Suction Temperature: **[40 deg F (4.4 deg C)]<Insert temperature>** .
 8. Superheat: **[Adjustable][Nonadjustable]** .
 9. Design: Reverse-flow option (for heat-pump applications).
 10. End Connections: Socket, flare, or threaded union.
 11. Working Pressure Rating: **[700 psig (4820 kPa)][450 psig (3100 kPa)]<Insert value>** .
- I. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
 3. Body, Bonnet, and Seal Cap: Ductile iron or steel.
 4. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 5. Packing and Gaskets: Non-asbestos.
 6. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 7. Seat: Polytetrafluoroethylene.
 8. Equalizer: **[Internal][External]** .
 9. Electrical: Molded, watertight coil in ANSI/NEMA 250 enclosure of type required by location with **1/2-inch (16-GRC)** conduit adapter and **[24][115][208]** V ac coil.
 10. End Connections: Socket.
 11. Set Pressure: **<Insert psig (kPa)>** .
 12. Throttling Range: Maximum **5 psig (34 kPa)**.
 13. Working Pressure Rating: **[500 psig (3450 kPa)]<Insert pressure>** .
 14. Maximum Operating Temperature: **[240 deg F (116 deg C)]<Insert temperature>** .
- J. Straight-Type Strainers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
3. Body: Welded steel with corrosion-resistant coating.
4. Screen: 100-mesh stainless steel.
5. End Connections: Socket or flare.
6. Working Pressure Rating: **[500 psig (3450 kPa)]<Insert pressure>** .
7. Maximum Operating Temperature: **[275 deg F (135 deg C)]<Insert temperature>** .

K. Angle-Type Strainers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
3. Body: Forged brass or cast bronze.
4. Drain Plug: Brass hex plug.
5. Screen: 100-mesh monel.
6. End Connections: Socket or flare.
7. Working Pressure Rating: **[500 psig (3450 kPa)]<Insert pressure>** .
8. Maximum Operating Temperature: **[275 deg F (135 deg C)]<Insert temperature>** .

L. Moisture/Liquid Indicators:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **[RLS LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **[RLS LLC]**
 - e. **<Insert manufacturer's name>**
 3. Body: Forged brass.
 4. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 5. Indicator: Color-coded to show moisture content in parts per million (ppm).
 6. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 7. End Connections: Socket or flare.
 8. Working Pressure Rating: **[500 psig (3450 kPa)]<Insert pressure>** .
 9. Maximum Operating Temperature: **[240 deg F (116 deg C)]<Insert temperature>** .
- M. Replaceable-Core Filter Dryers: Comply with **AHRI 730 I-P (AHRI 731 SI)**.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
 3. Body and Cover: Painted-steel shell with ductile-iron cover, stainless steel screws, and neoprene gaskets.
 4. Filter Media: 10 micron, pleated with integral end rings; stainless steel support.
 5. Desiccant Media: Activated **[alumina][charcoal]** .
 6. Design: Reverse flow (for heat-pump applications).

7. End Connections: Socket.
8. Access Ports: **NPS 1/4 (DN 8)** connections at entering and leaving sides for pressure differential measurement.
9. Maximum Pressure Loss: **[2 psig (14 kPa)]<Insert value>** .
10. Rated Flow: **<Insert tons (kW)>** .
11. Working Pressure Rating: **[500 psig (3450 kPa)]<Insert pressure>** .
12. Maximum Operating Temperature: **[240 deg F (116 deg C)]<Insert temperature>** .

N. Permanent Filter Dryers: Comply with **AHRI 730 I-P (AHRI 731 SI)**.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **[RLS LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Danfoss, Inc.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **[RLS LLC]**
 - e. **<Insert manufacturer's name>**
3. Body and Cover: Painted-steel shell.
4. Filter Media: 10 micron, pleated with integral end rings; stainless steel support.
5. Desiccant Media: Activated **[alumina][charcoal]** .
6. Design: Reverse flow (for heat-pump applications).
7. End Connections: Socket.
8. Access Ports: **NPS 1/4 (DN 8)** connections at entering and leaving sides for pressure differential measurement.
9. Maximum Pressure Loss: **[2 psig (14 kPa)]<Insert value>** .
10. Rated Flow: **<Insert tons (kW)>** .
11. Working Pressure Rating: **[500 psig (3450 kPa)]<Insert pressure>** .
12. Maximum Operating Temperature: **[240 deg F (116 deg C)]<Insert temperature>** .

O. Mufflers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Danfoss, Inc.]**
 - b. **[Emerson Climate Technologies; Emerson Electric Co.]**
 - c. **[Henry Technologies Inc.; The Henry Group]**
 - d. **[Parker Hannifin; Sporlan Division]**
 - e. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Danfoss, Inc.]**
 - b. **[Emerson Climate Technologies; Emerson Electric Co.]**
 - c. **[Henry Technologies Inc.; The Henry Group]**
 - d. **[Parker Hannifin; Sporlan Division]**
 - e. **<Insert manufacturer's name>**
3. Body: Welded steel with corrosion-resistant coating.
4. End Connections: Socket or flare.
5. Working Pressure Rating: **[500 psig (3450 kPa)]<Insert pressure>** .
6. Maximum Operating Temperature: **[275 deg F (135 deg C)]<Insert temperature>** .

P. Receivers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Henry Technologies Inc.; The Henry Group]**
 - b. **[Parker Hannifin; Sporlan Division]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Henry Technologies Inc.; The Henry Group]**
 - b. **[Parker Hannifin; Sporlan Division]**
 - c. **<Insert manufacturer's name>**
3. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
4. Comply with UL 207; listed and labeled by an NRTL.
5. Body: Welded steel with corrosion-resistant coating.
6. Tappings: Inlet, outlet, liquid-level indicator, and safety-relief valve.
7. End Connections: Socket or threaded.
8. Working Pressure Rating: **[450 psig (3100 kPa)]<Insert pressure>** .
9. Maximum Operating Temperature: **[250 deg F (121 deg C)]<Insert temperature>** .

Q. Liquid Accumulators:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Emerson Climate Technologies; Emerson Electric Co.]**
 - b. **[Henry Technologies Inc.; The Henry Group]**
 - c. **[Parker (Parker Hannifin)]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. [Emerson Climate Technologies; Emerson Electric Co.]
 - b. [Henry Technologies Inc.; The Henry Group]
 - c. [Parker (Parker Hannifin)]
 - d. <Insert manufacturer's name>
3. Body: Welded steel with corrosion-resistant coating.
 4. End Connections: Socket or threaded.
 5. Working Pressure Rating: [500 psig (3450 kPa)]<Insert pressure> .
 6. Maximum Operating Temperature: [275 deg F (135 deg C)]<Insert temperature> .

2.6 REFRIGERANTS

A. R-32, ASHRAE 34: Difluoromethane.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Arkema Inc.]
 - b. [Honeywell International Inc.]
 - c. [Mexichem Fluor, Inc. (Koura)]
 - d. [The Chemours Company]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arkema Inc.]
 - b. [Honeywell International Inc.]
 - c. [Mexichem Fluor, Inc. (Koura)]
 - d. [The Chemours Company]
 - e. <Insert manufacturer's name>

B. R-454B, ASHRAE 34: R-32 (68.9 percent by mass) and R-1234yf (31.1 percent by mass).

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [Arkema Inc.]
 - b. [Honeywell International Inc.]
 - c. [Mexichem Fluor, Inc. (Koura)]
 - d. [The Chemours Company]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Arkema Inc.]
- b. [Honeywell International Inc.]
- c. [Mexichem Fluor, Inc. (Koura)]
- d. [The Chemours Company]
- e. <Insert manufacturer's name>

PART 3 - EXECUTION

3.1 PIPING APPLICATION SCHEDULES

- A. Refrigerant: [R-454B][R-32]<Insert refrigerant> .
- B. Suction, Hot-Gas, and Liquid Tubing for Conventional Air-Conditioning (Cooling-Only) Applications, NPS 1-1/2 (DN 40) and Smaller, Annealed-Temper: Copper, Type ACR, annealed-temper tubing and **[wrought-copper fittings with brazed joints][ACR copper fittings with pressure-seal joints]** .
- C. Suction, Hot-Gas, and Liquid Tubing for Conventional Air-Conditioning (Cooling-Only) Applications, NPS 4 (DN 100) and Smaller, Drawn-Temper: Copper, Type ACR drawn-temper tubing and wrought-copper fittings with brazed joints.
- D. Suction, Hot-Gas, and Liquid Tubing for Conventional Air-Conditioning (Cooling-Only) Applications, NPS 2 to NPS 4 (DN 50 to DN 100), Drawn-Temper: Copper, Type ACR drawn-temper tubing and wrought-copper fittings with brazed joints.
- E. Safety-Relief-Valve Discharge Tubing for Conventional Air-Conditioning (Cooling-Only) Applications, Copper: Type ACR, **[drawn-temper][or][annealed-temper]** tubing and wrought-copper fittings with brazed joints.
- F. Safety-Relief-Valve Discharge Piping for Conventional Air-Conditioning (Cooling-Only) Applications, Steel: Schedule 40, black steel and wrought-steel fittings with welded joints.
- G. Suction, Hot-Gas, and Liquid Tubing for Heat-Pump Applications, NPS 1-1/2 (DN 40) and Smaller, Annealed-Temper: Copper, Type ACR, annealed-temper tubing and **[wrought-copper fittings with brazed joints][ACR copper fittings with pressure-seal joints]** .
- H. Suction, Hot-Gas, and Liquid Tubing for Heat-Pump Applications, NPS 4 (DN 100) and Smaller, Drawn-Temper: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.
- I. Suction, Hot-Gas, and Liquid Tubing for Heat-Pump Applications, NPS 2 to NPS 4 (DN 50 to DN 100), Drawn-Temper: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.
- J. Safety-Relief-Valve Discharge Tubing for Heat-Pump Applications, Copper: Type ACR, **[drawn-temper][or][annealed-temper]** tubing and wrought-copper fittings with brazed joints.
- K. Safety-Relief-Valve Discharge Piping for Heat-Pump Applications, Steel: Schedule 40, black steel and wrought-steel fittings with welded joints.
- L. Refrigerant Tubing for Variable Refrigerant Flow System Applications:
 - 1. Copper Tube: ASTM B280, Type ACR.
 - 2. Wrought-Copper Fittings, Brazed Joints: ASME B16.50.
 - 3. Brazing Filler Metals: AWS A5.8/A5.8M.



- M. Safety-Relief-Valve Discharge Tubing for VRF Applications, Copper: Type ACR, **[drawn-temper][or][annealed-temper]** tubing and wrought-copper fittings with brazed joints.
- N. Safety-Relief-Valve Discharge Piping for VRF Applications, Steel: Schedule 40, black steel and wrought-steel fittings with welded joints.

3.2 INSTALLATION OF VALVES AND SPECIALTIES

- A. Install **[diaphragm packless][packed-angle]** valves in suction and discharge lines of compressor.
- B. Install service valves for gauge taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install **[diaphragm packless][packed-angle]** valves on inlet and outlet side of filter dryers.
- E. Install a full-size, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety-relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside in accordance with ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- J. Strainers: Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Hot-gas bypass valves.
 - 4. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve [, **and in the suction line at the compressor**] .
- L. Install receivers sized to accommodate pump-down charge.
- M. Install flexible connectors at compressors.

- N. Provide refrigerant locking caps on refrigerant charging ports that are located outdoors unless otherwise protected from unauthorized access by a means acceptable to authority having jurisdiction.

3.3 INSTALLATION OF REFRIGERANT PIPING, GENERAL

- A. Requirements in this article apply to all piping materials, except where more specific requirements are specified in various pipe and fittings installation articles below.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- C. Install refrigerant piping in accordance with ASHRAE 15.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Install piping adjacent to machines to allow service and maintenance.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. See Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for solenoid valve controllers, control wiring, and sequence of operation.
- L. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- M. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- N. Install refrigerant piping in protective conduit where installed belowground.
- O. Install refrigerant piping in rigid or flexible conduit in locations where exposed to potential mechanical injury.
- P. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.

- Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- R. Identify refrigerant piping and valves in accordance with Section 230553 "Identification for HVAC Piping and Equipment."
- S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."
- T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common Work Results for HVAC."
- U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

3.4 INSTALLATION OF COPPER TUBE AND FITTINGS

- A. When brazing copper tubing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- B. Joint Construction:
 - 1. Ream ends of tubes and remove burrs.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
 - 3. Brazed Joints: Construct joints in accordance with AWS BRH, "Brazing Handbook," Ch. 35, "Pipe and Tubing."
 - a. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
 - b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.
 - 4. Copper-tube, Pressure-Seal-Joint Fittings: Construct joints in accordance with manufacturer's written instructions.

3.5 INSTALLATION OF STEEL PIPE AND FITTINGS

- A. Pre-Installation Cleaning: Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
 - 1. Shot blast the interior of piping.
 - 2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
 - 3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
 - 4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
 - 5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
 - 6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.
- B. Joint Construction:

1. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
4. Threaded Joints: Thread steel pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and to restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
5. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.
6. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12.
7. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic restraints in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- C. Piping Attachments: Install the following pipe attachments:
 1. Adjustable steel clevis hangers for individual horizontal runs less than **20 ft. (6 m)** long.
 2. Roller hangers and spring hangers for individual horizontal runs **20 ft. (6 m)** or longer.
 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping **20 ft. (6 m)** or longer, supported on a trapeze.
 4. Spring hangers to support vertical runs.
 5. Copper-clad hangers and supports for hangers and supports in direct contact with copper tube.
- D. Install hangers for metal tubing and piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Support horizontal piping within [**12 inches (300 mm)**]**<Insert dimension>** of each fitting.
- F. Support vertical runs of metal tubing and piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: [**Owner will engage**][**Engage**] a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System must maintain test pressure at the manifold gauge throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.
4. Prepare test and inspection reports.

3.8 SYSTEM CHARGING

- A. Procedures: Charge system using the following procedures:
1. Install core in filter dryers after leak test but before evacuation.
 2. Evacuate entire refrigerant system with a vacuum pump to **500 micrometers (67 Pa)**. If vacuum holds for 12 hours, system is ready for charging.
 3. Break vacuum with refrigerant gas, allowing pressure to build up to **2 psig (14 kPa)**.
 4. Charge system with a new filter-dryer core in charging line.

3.9 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Adjustments: Perform the following adjustments before operating the refrigeration system, in accordance with manufacturer's written instructions:
1. Open shutoff valves in condenser water circuit.
 2. Verify that compressor oil level is correct.
 3. Open compressor suction and discharge valves.
 4. Open refrigerant valves but not bypass valves that are used for other purposes.
 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 23 00 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 23 13 00	23 23 00 00	Refrigerant Piping
23 23 16 00	21 05 00 00	Common Work Results for Fire Suppression
23 23 16 00	22 05 00 00	Common Work Results for Plumbing
23 23 16 00	22 13 16 00	Sanitary Waste And Vent Piping
23 23 16 00	22 11 16 00a	Storm Drainage Piping
23 23 16 00	23 05 00 00	Common Work Results for HVAC
23 23 16 00	23 21 13 00	Hydronic Piping
23 23 16 00	23 23 00 00	Refrigerant Piping
23 23 16 00	23 62 00 00	Packaged Compressor and Condenser Units
23 23 23 00	23 23 00 00	Refrigerant Piping
23 23 23 00	23 62 00 00	Packaged Compressor and Condenser Units



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 25 00 00 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. HVAC water treatment.
2. Manual chemical-feed equipment.
3. Automatic chemical-feed equipment.
4. Ozone-generator biocide equipment.
5. Stainless steel pipes and fittings.
6. UV biocide equipment.
7. Chemical-treatment test equipment.
8. Chemicals.
9. Inhibited ethylene glycol and propylene glycol.
10. HVAC makeup-water softener.
11. RO equipment for HVAC makeup water.
12. Filtration equipment.

1.2 DEFINITIONS

- A. EEPROM: Electrically erasable, programmable read-only memory.
- B. PPM: Parts per million.
- C. RO: Reverse osmosis.
- D. TDS: Total dissolved solids consist of salts and other materials that combine with water as a solution.
- E. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
 1. Bypass feeders.
 2. Water meters.
 3. Inhibitor injection timers.
 4. pH controllers.
 5. TDS controllers.
 6. TSS controllers.
 7. Biocide feeder timers.
 8. Chemical solution tanks.
 9. Injection pumps.
 10. Ozone generators.
 11. UV-irradiation units.

12. Chemical test equipment.
13. Chemical material safety data sheets.
14. Inhibited ethylene glycol.
15. Inhibited propylene glycol.
16. Water softeners.
17. RO units.
18. Multimedia filters.
19. Self-cleaning strainers.
20. Replaceable bag- or cartridge-type filters.
21. Centrifugal separators.

- B. Shop Drawings: Pretreatment equipment and chemical- **[and ozone-generator-biocide-][and UV-irradiation-biocide-]** treatment equipment, showing tanks, maintenance space required, and piping connections to HVAC systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For **[chemical-treatment equipment][water softeners][RO equipment][water-filtration units]** and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- C. Field quality-control reports.
- D. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
- E. Water Analysis: Illustrate water quality available at Project site.
- F. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, **[water softeners,][RO equipment,][water-filtration units,]** and controllers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 HVAC WATER TREATMENT

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Anderson Chemical Company]**
2. **[Aqua-Chem, Inc.]**
3. **[Barclay Water Management, Inc]**
4. **[Boland Trane Services]**
5. **[Cascade Water Services, Inc]**
6. **[Earthwise Environmental Inc]**
7. **[H-O-H Water Technology, Inc]**
8. **[LiquiTech, Inc.]**
9. **[Metro Group, Inc. (The)]**
10. **[Nalco; an Ecolab company]**
11. **[Sonitec-Vortisand Inc.]**
12. **[Suez Water Technologies (Formerly GE Water)]**
13. **[Watcon, Inc]**
14. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Anderson Chemical Company]**
2. **[Aqua-Chem, Inc.]**
3. **[Barclay Water Management, Inc]**
4. **[Boland Trane Services]**
5. **[Cascade Water Services, Inc]**
6. **[Earthwise Environmental Inc]**
7. **[H-O-H Water Technology, Inc]**
8. **[LiquiTech, Inc.]**
9. **[Metro Group, Inc. (The)]**
10. **[Nalco; an Ecolab company]**
11. **[Sonitec-Vortisand Inc.]**
12. **[Suez Water Technologies (Formerly GE Water)]**
13. **[Watcon, Inc]**
14. **<Insert manufacturer's name>**

2.2 PERFORMANCE REQUIREMENTS

- A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems as indicated in this Specification. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or to the environment.

- B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C. Closed hydronic systems, including **[hot-water heating below 250 deg F (120 deg C)][chilled water][dual-temperature water][glycol heating][and][glycol cooling]** shall have the following water qualities:
1. pH: Maintain a value within **<Insert range>**.
 2. Alkalinity: Maintain a value within **<Insert range>** mg/L as CaCO₃.
 3. Steel Corrosion Inhibitors: Provide sufficient inhibitors to limit mild steel corrosion to **<Insert number>** mils per year. Maintain soluble iron concentrations at or below **<Insert value>** mg/L.
 4. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to **<Insert number>** mils per year. Maintain soluble copper concentrations at or below **<Insert value>** mg/L.
 5. Scale Control: Provide softened water for initial fill and makeup. **[Where softened water is not used, provide sufficient scale inhibitors to prevent formation of scale and maintain all scale-forming material in solution.]**
 6. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
 7. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of **<Insert number>** organisms/mL.
 - b. Total Anaerobic Plate Count: Maintain a maximum value of **<Insert number>** organisms/mL.
 - c. Nitrate Reducers: Maintain a maximum value of **<Insert number>** organisms/mL.
 - d. Sulfate Reducers: Maintain a maximum value of **<Insert number>** organisms/mL.
 - e. Iron Bacteria: Maintain a maximum value of **<Insert number>** organisms/mL.
 8. **<Insert other applicable requirements>**.
- D. Open hydronic systems, including **[condenser][and][fluid-cooler spray]** water, shall have the following water qualities:
1. pH: Maintain a value within **<Insert range>**.
 2. Alkalinity: Maintain a maximum value of **<Insert range>** mg/L as CaCO₃.
 3. Silica in Cooling Towers: Maintain a value no higher than **<Insert number>** mg/L.
 4. Silica in Evaporative Condensers: Maintain a value no higher than **<Insert number>** mg/L.
 5. Hardness in Cooling Towers: Maintain a value no higher than **<Insert value>** mg/L as CaCO₃.
 6. Hardness in Evaporative Condensers: Maintain a value no higher than **<Insert value>** mg/L as CaCO₃.
 7. Steel Corrosion Inhibitors: Provide sufficient inhibitors to limit mild steel corrosion to **<Insert number>** mils per year. Maintain soluble iron concentrations at or below **<Insert value>** mg/L.
 8. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to **<Insert value>** mils per year. Maintain soluble copper concentrations at or below **<Insert value>** mg/L.
 9. Scale Control: **[Provide softened water for initial fill and makeup.][Provide sufficient scale inhibitors to prevent formation of scale and maintain all scale-forming material in solution.]**
 10. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
 11. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of **<Insert number>** organisms/mL.
 - b. Total Anaerobic Plate Count: Maintain a maximum value of **<Insert number>** organisms/mL.
 - c. Nitrate Reducers: Maintain a maximum value of **<Insert number>** organisms/mL.

- d. Sulfate Reducers: Maintain a maximum value of **<Insert number>** organisms/mL.
- e. Iron Bacteria: Maintain a maximum value of **<Insert number>** organisms/mL.

12. **<Insert other applicable requirements>**.

E. Passivation for Galvanized Steel:

- 1. Passivation of all galvanized-steel cooling towers and other system components must be conducted strictly in accordance with manufacturer's instructions in order to validate warranties. During the required passivation period, all water-quality parameters must be maintained in accordance with manufacturer's specifications, and all other requirements must be observed.

F. Steam Boiler and Steam Condensate:

1. Steam Condensate:

- a. pH: Maintain a value within **<Insert range>**.
- b. Alkalinity: Maintain a value no higher than **<Insert range>** mg/L as CaCO₃.
- c. Steel Corrosion Inhibitors: Provide sufficient inhibitors to limit mild steel corrosion to **<Insert number>** mils per year. Maintain soluble iron concentrations at or below **<Insert value>** mg/L.
- d. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to **<Insert value>** mils per year. Maintain soluble copper concentrations at or below **<Insert value>** mg/L.
- e. Ammonia: Maintain a value of **<Insert number>** mg/L.
- f. **<Insert other requirements if necessary>**.

2. Steam boiler operating at **100 psig (690 kPa)** and less shall have the following water qualities:

- a. Silica: Maintain a value no higher than **<Insert value>** mg/L as SiO₂.
- b. TSS: Maintain a value no higher than **<Insert value>** mg/L.
- c. TDS: Maintain a value no higher than **<Insert value>** mg/L.
- d. Total Alkalinity: Maintain a value no higher than **<Insert value>** mg/L as CaCO₃.
- e. pH: Maintain a value within **<Insert range>** pH.
- f. **<Insert other applicable requirements>**.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

- A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum **3-1/2-inch (89-mm)** fill opening in the top, and **NPS 3/4 (DN 20)** bottom inlet and top side outlet. Provide quarter- turn or threaded fill cap with gasket seal and diaphragm arranged to lock the top onto the feeder when exposed to system pressure in the vessel. Provide a **NPS 3/4 IN (DN 20)** quarter-turn valve on inlet and outlet.

- 1. Capacity: **[2 gal. (7.6 L)][5 gal. (19 L)]<Insert value>**.
- 2. Minimum Working Pressure: **[125 psig (860 kPa)][175 psig (1210 kPa)]<Insert value>**.

2.4 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter, Oscillating Piston:

- 1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
- 2. Body: Bronze.
- 3. Minimum Working-Pressure Rating: **150 psig (1035 kPa)**.
- 4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.

5. Registration: **Gallons (Liters) or cubic feet (cubic meters).**
6. End Connections: Threaded.
7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
8. **[Provide an electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
9. **[All electrical components, devices, and accessories must be listed and labeled as defined in NFPA 70, by a qualified testing agency, and must be marked for intended location and application.]**

B. Water Meter, Turbine Type, Threaded:

1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: **100 psig (690 kPa).**
4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa).**
5. Registration: **Gallons (Liters) or cubic feet (cubic meters).**
6. End Connections: Threaded.
7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
8. **[Provide an electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
9. **[All electrical components, devices, and accessories must be listed and labeled as defined in NFPA 70, by a qualified testing agency, and must be marked for intended location and application.]**

C. Water Meter, Turbine Type, Flanged:

1. AWWA C701, turbine-type, totalization meter.
2. Body: **[Bronze][Epoxy-coated cast iron].**
3. Minimum Working-Pressure Rating: **150 psig (1035 kPa).**
4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa).**
5. Registration: **Gallons (Liters) or cubic feet (cubic meters).**
6. End Connections: Flanged.
7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
8. **[Provide an electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
9. **[All electrical components, devices, and accessories must be listed and labeled as defined in NFPA 70, by a qualified testing agency, and must be marked for intended location and application.]**

D. Inhibitor Injection Timers:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]**
2. Programmable timers with infinite adjustment over full range, mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.

5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. Digital display makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.

E. pH Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. [**Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."**]
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High or low-pH-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.

F. TDS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. [**Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."**]
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves:
 - a. Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
 - b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

G. TSS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from 0.001 mg/L to 50 g/L. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 4X enclosure. [**Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."**]
2. [**Forms of digital communication:][MODBUS RS-232][MODBUS RS-485][Profibus DP].**
3. Digital display and touch pad for input.
4. Sensor probe adaptable to sample stream manifold.
5. High- or low-value-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.

H. Biocide Feeder Timer:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with

gasketed and lockable door. [**Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."**]

2. 24-hour timer with 14-day skip feature to permit activation any hour of day.
3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
4. Solid-state alternator to enable use of two formulations.
5. 24-hour display of time of day.
6. 14-day display of day of week.
7. Battery backup, so clock is not disturbed by power outages.
8. Hand-off-auto switches for biocide pumps.
9. Biocide A and Biocide B pump running indication.

I. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: [30 gal. (114 L)][50 gal. (189 L)][120 gal. (454 L)]<Insert value>.

J. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230500 "Common Work Results for HVAC."
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

K. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints, except ASTM A269/A269M, Type 304 stainless steel for steam boiler injection assemblies.

L. Injection Assembly:

1. Quill: Minimum **NPS 1/2 (DN 15)** with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: [Three][Two]-piece stainless steel, as described in "Stainless Steel Pipes and Fittings" Article; selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum **600 psig (4137 kPa) at 200 deg F (93 deg C)**.

2.5 OZONE-GENERATOR BIOCIDES EQUIPMENT

- A. Corona discharge generator with stainless steel generating cells and transformer housed in a NEMA 250, Type 4 enclosure. Assembly shall be suitable for continuous duty. Provide site glasses to verify proper operation of generator.
- B. Water-cooled generators shall be provided with cooling water at maximum [70 deg F (21 deg C)]<Insert value> and [35 psig (241 kPa)]<Insert value>.

- C. Generator vessels exposed to system pressure shall be constructed in accordance with 2017 ASME Boiler and Pressure Vessel Code and be equipped with pressure-relief valve.
- D. External air compressor or induced airflow through a cleanable prefilter supplies concentrated oxygen through a molecular sieve, with **minus 62 deg F (minus 52 deg C)** dew point to avoid the formation of nitric acid.
- E. Microprocessor-based control with software in EEPROM, surge protection, high-temperature cutout, and operational status lights. [**Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."**]
- F. Ozone Contactors:
 - 1. Bubble diffusers.
 - 2. Induction injection nozzle.
 - 3. Injectors with static mixers.
- G. Ozone Detector and Alarm Devices:
 - 1. Detector:
 - a. Sensor: Metal dioxide semiconductor.
 - b. Concentration Range: **[0 to 10]<Insert range>** ppm.
 - c. Accuracy: Plus or minus 0.01 ppm.
 - d. Sensitivity: 0.01 ppm.
 - e. Response Time: Maximum 10 seconds.
 - f. Operating Temperature: **50 to 100 deg F (10 to 38 deg C)**.
 - g. Relative Humidity: 15 to 90 percent, noncondensing over the operating temperature range.
 - 2. Horns:
 - a. Electric-vibrating-polarized type.
 - b. 24-V dc, with provision for housing the operating mechanism behind a grille.
 - c. Horns shall produce a sound-pressure level of 90 dBA, measured **10 feet (3 m)** from the horn.
 - d. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. Visible Alarm Devices:
 - a. Xenon strobe lights listed in UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate.
 - b. Rated Light Output: **[75][110]<Insert number>** candela.
 - c. Strobe Leads: Factory connected to screw terminals.
- H. Self-Contained Breathing Apparatus: Open-circuit, pressure-demand compressed air includes completely assembled, portable, self-contained devices designed for hazardous breathing environment application.
 - 1. Face Piece: EPDM or silicone rubber construction material, one-size-fits-all with double-sealing edge, stainless steel speaking diaphragm and lens retainer, five adjustable straps to hold face piece to head (two straps on each side and one on top), exhalation valve in mask, close-fitting nose piece to ensure no CO(2) buildup, and perspiration drain to avoid skin irritation and to prevent eyepiece, spectacle, and lens fogging.
 - 2. Backplate: Orthopedically designed of **[chemical and impact-resistant, glass-fiber composite][aluminum]**.

3. Harness and Carrier Assembly: Large triangular back pad, backplate, and adjustable waist and shoulder straps; modular in design, detachable components, and easy to clean and maintain. Shoulder straps are padded with flame-resistant material, reinforced with stainless steel cable, and attached with T-nuts, washers, and screws.
4. Air Cylinder: **[30][45][60]**-minute, low-pressure, air-supply-loaded **[fiberglass][aluminum][steel]** cylinders fitted with quick-fill assembly for refilling and air transfer.
5. Wall-Mounting Cabinet: Leakproof, corrosion-resistant, clear, plastic case.
6. Tested and Certified: By the National Institute for Occupational Safety and Health and by the Mine Safety and Health Administration, in accordance with 42 CFR 84, Subpart H.

2.6 STAINLESS STEEL PIPES AND FITTINGS

- A. Stainless Steel Tubing: Comply with ASTM A269/A269M, Type 316.
- B. Stainless Steel Fittings: Comply with ASTM A815/A815M, Type 316, Grade WP-S.
- C. Two-Piece, Full-Port, Stainless Steel Ball Valves: ASTM A351/A351M, Type 316 stainless steel body; ASTM A276/A276M, Type 316 stainless steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and **250-psig (1725-kPa)** steam working pressure and **600-psig (4140-kPa)** cold working pressure ratings.
- D. Three-Piece, Full-Port, Stainless Steel Ball Valves: ASTM A351/A351M, Type 316 stainless steel body; ASTM A276/A276M, Type 316 stainless steel stem and vented ball, threaded body design with adjustable stem packing, threaded ends, and **150-psig (1035-kPa)** steam working pressure and **600-psig (4140-kPa)** cold working pressure rating.

2.7 UV BIOCIDES EQUIPMENT

- A. Target Irradiation: Minimum **[5,000 microWxs/sq. cm]<Insert value>**.
- B. Light Source Vessels:
 1. ASTM A666, Type 304 stainless steel.
 2. Construct for minimum **[150 psig (1035 kPa)]<Insert value>** at **[150 deg F (65 deg C)]<Insert value>** in accordance with ASME Boiler and Pressure Vessel Code, and equipped with pressure-relief valve.
 3. Light Source Sleeve: Quartz, with EPDM O-ring seals.
 4. Light Source: Replaceable UV lamp producing minimum target irradiation of 254-nm wavelength light.
- C. Controls: Interlock with pumps to operate when water is circulating.

2.8 CHEMICAL-TREATMENT TEST EQUIPMENT

- A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounted cabinet for testing pH, TSS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers; and oxidizing biocide test for open cooling systems.
- B. Sample Cooler:
 1. Tube: Sample.

- a. Size: **NPS 1/4 (DN 8)** tubing.
 - b. Material: ASTM A666, Type 316 stainless steel.
 - c. Pressure Rating: Minimum **2000 psig (13 790 kPa)**.
 - d. Temperature Rating: Minimum **850 deg F (454 deg C)**.
2. Shell: Cooling water.
 - a. Material: ASTM A666, Type 304 stainless steel.
 - b. Pressure Rating: Minimum **250 psig (1725 kPa)**.
 - c. Temperature Rating: Minimum **450 deg F (232 deg C)**.
3. Capacities and Characteristics:
 - a. Tube: Sample.
 - 1) Flow Rate: **[0.25 gpm (0.016 L/s)]<Insert value>**.
 - 2) Entering Temperature: **[400 deg F (204 deg C)]<Insert value>**.
 - 3) Leaving Temperature: **[88 deg F (31 deg C)]<Insert value>**.
 - 4) Pressure Loss: **[6.5 psig (44.8 kPa)]<Insert value>**.
 - b. Shell: Cooling water.
 - 1) Flow Rate: **[3 gpm (0.19 L/s)]<Insert value>**.
 - 2) Entering Temperature: **[70 deg F (21 deg C)]<Insert value>**.
 - 3) Pressure Loss: **[1.0 psig (6.89 kPa)]<Insert value>**.
- C. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
 1. **[Two]<Insert number>**-station rack for closed-loop systems.
 2. **[Four]<Insert number>**-station rack for open-loop systems.

2.9 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.
- B. Chemicals for direct steam injection humidification and for steam used in direct contact with food to be FDA approved and safe for these uses.
- C. Water Softener Chemicals:
 1. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range, with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum **<Insert grains/cu. ft. (kg/cu. m)>** of calcium carbonate of resin when regenerated with **<Insert lb (kg)>** of salt.
 2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are unacceptable.

2.10 INHIBITED ETHYLENE GLYCOL AND PROPYLENE GLYCOL

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[CORECHEM]**
 2. **[Dynalene]**
 3. **[Fremont Industries]**
 4. **[Houghton Chemical Corp.]**
 5. **[The Dow Chemical Company]**
 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[CORECHEM]**
 2. **[Dynalene]**
 3. **[Fremont Industries]**
 4. **[Houghton Chemical Corp.]**
 5. **[The Dow Chemical Company]**
 6. **<Insert manufacturer's name>**
- C. Inhibited Ethylene Glycol:
1. Ethylene glycol with inhibitor additive, to provide freeze protection for heat-transfer fluid and corrosion protection for carbon-steel, brass, copper, stainless steel, and cast-iron piping and fittings.
 2. Inhibitor creates a passive layer on all surfaces that contact ethylene glycol to prevent corrosion by stabilizing fluid pH, to compensate for acids formed from glycol degradation.
 3. pH value shall be maintained between **<Insert range>**, with reserve alkalinity greater than **<Insert number>** mL.
 4. Operating Temperature Range: **[Minus 60 deg F (minus 51 deg C) to 250 deg F (121 deg C)]<Insert range>**.
 5. Concentrated inhibited ethylene glycol is to be 95.5 percent ethylene glycol by weight and 4.5 percent performance additives.
 6. Concentrated inhibited ethylene glycol is mixed with water in proper proportion specified by the manufacturer to provide freeze protection to **[minus 20 deg F (minus 29 deg C)]<Insert number>**. Premixed heat-transfer fluid may be used, or glycol/water mixture may be prepared at time of installation. Use only deionized water for mixing.
 7. Provide only ethylene glycol that is specifically blended for HVAC application. Automotive-type antifreeze is unacceptable.
- D. Inhibited Propylene Glycol:
1. Propylene glycol with inhibitor additive, to provide freeze protection for heat-transfer fluid and corrosion protection for carbon-steel, brass, copper, stainless steel, and cast-iron piping and fittings.
 2. Inhibitor creates a passive layer on all surfaces that contact propylene glycol to prevent corrosion and stabilizes fluid pH, to compensate for acids formed from glycol degradation.
 3. pH value shall be maintained between **<Insert range>**, with reserve alkalinity greater than **<Insert number>** mL.
 4. Operating Temperature Range: **[Minus 50 deg F (minus 46 deg C) to 250 deg F (121 deg C)]<Insert range>**.
 5. Concentrated inhibited propylene glycol is to be 95.5 percent propylene glycol by weight and 4.5

- percent performance additives.
6. Concentrated inhibited propylene glycol is mixed with water in proper proportion specified by the manufacturer to provide freeze protection to **[minus 20 deg F (minus 29 deg C)]<Insert number>**. Premixed heat-transfer fluid may be used, or glycol/water mixture may be prepared at the time of installation. Use only deionized water for mixing.
 7. Provide only propylene glycol that is specifically blended for HVAC application. Automotive-type antifreeze is unacceptable.

2.11 HVAC MAKEUP-WATER SOFTENER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[3M]**
2. **[CSI Water Treatment Systems]**
3. **[Culligan International Company]**
4. **[Diamond Water Conditioning; a Griesbach company]**
5. **[Ecodyne Limited]**
6. **[Hungerford & Terry, Inc]**
7. **[Kinetico Incorporated]**
8. **[Marlo Incorporated]**
9. **[Parker Boiler]**
10. **[Pentair, Inc.]**
11. **[RainSoft]**
12. **[Water King]**
13. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[3M]**
2. **[CSI Water Treatment Systems]**
3. **[Culligan International Company]**
4. **[Diamond Water Conditioning; a Griesbach company]**
5. **[Ecodyne Limited]**
6. **[Hungerford & Terry, Inc]**
7. **[Kinetico Incorporated]**
8. **[Marlo Incorporated]**
9. **[Parker Boiler]**
10. **[Pentair, Inc.]**
11. **[RainSoft]**
12. **[Water King]**
13. **<Insert manufacturer's name>**

- C. Description: Twin mineral tanks and one brine tank, factory mounted on skid.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event, when tank supports are anchored to building structure as recommended in writing by manufacturer.
- F. Mineral Tanks:

1. Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Fabricate and label fiber-reinforced plastic filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
3. Pressure Rating: **[100 psig (690 kPa)][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert value>** minimum.
4. Wetted Components: Suitable for water temperatures from **[40 to at least 100 deg F (5 to at least 38 deg C)]<Insert range>**.
5. Freeboard: 50 percent minimum, for backwash expansion above the normal resin bed level.
6. Support Legs or Skirt: Constructed of structural steel, welded or bonded to tank before testing and labeling.
7. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication.
8. Upper Distribution System: Single-point type, fabricated from galvanized-steel pipe and fittings.
9. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging polyethylene strainers; arranged for even-flow distribution through resin bed.

G. Controls: Automatic; factory mounted on mineral tanks and factory wired.

1. Adjustable duration of regeneration steps.
2. Push-button start and complete manual operation override.
3. Pointer on pilot-control valve shall indicate cycle of operation.
4. Means of manual operation of pilot-control valve if power fails.
5. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:
 - a. Slow opening and closing, nonslam operation.
 - b. Diaphragm guiding on full perimeter from fully open to fully closed.
 - c. Isolated dissimilar metals within valve.
 - d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
 - e. Float-operated brine valve to automatically measure the correct amount of brine to the softener, and refill with fresh water.
 - f. Sampling cocks for soft water.
6. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in **gallons (liters)** and that automatically resets after regeneration to preset total in **gallons (liters)** for next service run. Include alternator to regenerate one mineral tank with the other in service.

H. Brine Tank: Combination measuring and wet-salt storing system.

1. Tank and Cover Material: Fiberglass a minimum of **3/16 inch (4.8 mm)** thick; or molded polyethylene a minimum of **3/8 inch (9.5 mm)** thick.
2. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
3. Size: Large enough for at least four regenerations at full salting.

I. Factory-Installed Accessories:

1. Piping, valves, tubing, and drains.
2. Sampling cocks.
3. Main-operating-valve position indicators.
4. Water meters.

- J. Water Test Kit: Include in wall-mounted enclosure for water softener.
- K. Capacities and Characteristics:
1. Continuous Service Flow Rate: **<Insert gpm (L/s)> at 15-psig (104-kPa)** pressure loss.
 2. Peak Service Flow Rate: **<Insert gpm (L/s)> at 25-psig (173-kPa)** pressure loss.
 3. Water Consumption: **<Insert gal./day (cu. m/day)>**.
 4. Water Demand: **<Insert number> hours/day**.
 5. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.
 - g. Interrupting Capacity: **<Insert amperage>**.

2.12 RO EQUIPMENT FOR HVAC MAKEUP WATER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[3M]**
 2. **[CSI Water Treatment Systems]**
 3. **[Culligan International Company]**
 4. **[Diamond Water Conditioning; a Griesbach company]**
 5. **[Ecodyne Limited]**
 6. **[Marlo Incorporated]**
 7. **[Pentair, Inc.]**
 8. **[Water & Power Technologies Incorporated]**
 9. **[Water King]**
 10. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[3M]**
 2. **[CSI Water Treatment Systems]**
 3. **[Culligan International Company]**
 4. **[Diamond Water Conditioning; a Griesbach company]**
 5. **[Ecodyne Limited]**
 6. **[Marlo Incorporated]**
 7. **[Pentair, Inc.]**
 8. **[Water & Power Technologies Incorporated]**
 9. **[Water King]**
 10. **<Insert manufacturer's name>**
- C. Description: Factory fabricated and tested with RO membrane elements in housings, high-pressure pumps and motors, controls, valves, and prefilter; mounted on skid.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- E. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.
- F. Skid Assembly: Welded-steel frame coated with epoxy protective finish.
- G. RO Membrane and Housing:
 - 1. Element: Thin-film composite with U-cup brine seal, with minimum 98 percent salt rejection based on 2000-ppm water supplied at **225 psig (1551 kPa)** and **77 deg F (25 deg C)**.
 - 2. Housing: ASTM A666, Type 304 stainless steel, with PVC end caps held in place with stainless steel straps.
- H. High-Pressure Pumps and Motors:
 - 1. Pump:
 - a. Vertical, multistage, centrifugal pump, operating at 3500 rpm, with ASTM A666, Type 304 stainless steel casing, shaft, impellers, and inlet and discharge casting.
 - b. Bearings shall be tungsten carbide and ceramic.
 - c. Cast-iron frame and flanged suction and discharge connections.
 - d. Motor: NEMA-standard, C-faced, totally enclosed, fan-cooled motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
- I. Controls:
 - 1. Microprocessor-based controller with digital display.
 - 2. Interlock for remote start/stop control.
 - 3. Membrane flush sequence when pumps shut down.
 - 4. Run time indicator.
 - 5. Low-pressure safety cutoff.
 - 6. Panel-mounted gages as follows:
 - a. Product and concentrate.
 - b. Inlet, cartridge filter outlet, RO feed, RO concentrate, and RO product pressures.
 - c. Product conductivity monitor.
- J. Valves:
 - 1. Stainless steel pump, concentrate, and recycle throttling valves rated for minimum **300 psig (2068 kPa)**.
 - 2. Automatic inlet shutoff valve, diaphragm type; solenoid actuated, normally closed, and constructed of glass-reinforced noryl thermoplastic.
 - 3. PVC valves with EPDM seats and seals for isolation at inlet, and check and sample valves at product and concentrate. Install sample valves at cartridge filter outlet, concentrate, and product outlet.
- K. Prefilter:
 - 1. Housing: Polypropylene with built-in relief or vent valve.
 - 2. Element: Spun-wound polypropylene.
- L. Inlet Water-Tempering Valve: Thermostatic water-tempering valve to maintain [**77 deg F (25 deg C)**]**<Insert value>** inlet water temperature to RO unit.

M. Activated Carbon Filter:

1. Media Tank: Fiberglass-reinforced polyester rated for minimum **150 psig (1035 kPa)** with internal backwash distributor and filtered water collector.
2. Media: 12-by-40-mesh, bituminous coal-based activated carbon.
3. Backwash Valve: Piston-operated control valve with drain-line, flow-control orifice.
4. Backwash Control: Seven-day time clock.

N. Atmospheric Storage Tank:

1. Tank: Polyethylene single piece with closed top and flat bottom with manway in top, 0.2-micron filter vent, inlet, discharge, and drain piping connections, and bulkhead fittings for level controls.
2. Control: Level switches start and stop RO unit. Low-level limit shall stop repressurization pumps and signal an alarm.

O. Repressurization Pumps:

1. Pumps: Two close-coupled, single-stage centrifugal pumps with mechanical seals. Wetted components are made of ASTM A666, Type 316 stainless steel.
2. Controls: NEMA 250, Type 4X pump control panel constructed of fiberglass to control pumps, one operating and one standby, with automatic alternator and fail-over control.
3. Motor: Open, drip-proof motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 - a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

P. Water Test Kit: Include in wall-mounting cabinet for RO unit.

Q. Capacities and Characteristics:

1. RO Product Flow Rate: **<Insert gpm (L/s)>**.
2. Total Water-Flow Rate: **<Insert gpm (L/s)>**.
3. Daily Water Consumption: **<Insert gal./day (cu. m/day)>**.
4. Water Demand: **<Insert number>** hours/day.
5. Storage Tank Size: **<Insert gal. (L)>**.
6. RO Inlet Operating Temperature: **[77 deg F (25 deg C)]<Insert value>**.
7. High-Pressure Pump:
 - a. Discharge Pressure: **<Insert psig (kPa)>**.
 - b. Flow Rate: **<Insert gpm (L/s)>**.
 - c. Horsepower: **<Insert value>**.
 - d. Motor Speed: **[3500]<Insert number>** rpm.
8. Repressure Pumps:
 - a. Discharge Pressure: **<Insert psig (kPa)>**.
 - b. Flow Rate: **<Insert gpm (L/s)>**.
 - c. Horsepower: **<Insert value>**.
 - d. Motor Speed: **[3500]<Insert number>** rpm.
9. Prefilter Design (at Total Water-Flow Rate):
 - a. Filter Efficiency: **[98]<Insert number>** percent.
 - b. Particle Size: **[5]<Insert number>** microns and larger.
 - c. Clean Pressure Loss: **[2 psig (14 kPa)]<Insert value>**.

d. Replacement Pressure Loss: **[6 psig (41 kPa)]<Insert value>**.

10. Electrical Characteristics (Single-Point Connection):

- a. Volts: **<Insert value>**.
- b. Phase: **<Insert value>**.
- c. Hertz: **<Insert value>**.
- d. Full-Load Amperes: **<Insert value>**.
- e. Minimum Circuit Ampacity: **<Insert value>**.
- f. Maximum Overcurrent Protection: **<Insert amperage>**.
- g. Interrupting Capacity: **<Insert amperage>**.

2.13 FILTRATION EQUIPMENT

A. Multimedia Filters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Diamond Water Conditioning; a Griesbach company]**
 - b. **[Everfilt]**
 - c. **[LAKOS Filtration Solutions]**
 - d. **[Miami Filter, Inc.]**
 - e. **[PEP Filters, Inc.]**
 - f. **[Puroflux Corporation]**
 - g. **[Sonitec-Vortisand Inc.]**
 - h. **[United Industries, Inc; Tower-flo Water Systems]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Diamond Water Conditioning; a Griesbach company]**
 - b. **[Everfilt]**
 - c. **[LAKOS Filtration Solutions]**
 - d. **[Miami Filter, Inc.]**
 - e. **[PEP Filters, Inc.]**
 - f. **[Puroflux Corporation]**
 - g. **[Sonitec-Vortisand Inc.]**
 - h. **[United Industries, Inc; Tower-flo Water Systems]**
 - i. **<Insert manufacturer's name>**
3. Description: Factory-fabricated and -tested, simplex, multimedia filter system, consisting of filter tank, media, strainer, circulating pump, piping, and controls for removing particles from water.
 - a. Filter Tank: Corrosion resistant with distribution system and media.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - a. Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel

- Code: Section VIII, Division 1.
- b. Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
 - c. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - d. Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606.
 - e. FRP Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Type A, integral; **[Designation E, 125-psig (0.862-MPa)][or][Designation F, 150-psig (1.034-MPa)]** pressure category flanges of grade same as tank material, in accordance with ASTM D5421.
 - f. Motorized Valves: Flanged or grooved-end, ductile-iron butterfly type with **[EPDM]<Insert material>** valve seat and stem seal; with ASTM B148 aluminum bronze disc.
 - g. Strainer: Basket type mounted on pump suction.
 - h. Piping:
 - 1) ASTM A53/A53M; Type S, F, or E; Grade B; Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding or ductile-iron fittings.
 - 2) **ASTM B88, Type L (ASTM B88M, Type B)** copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
 - i. Safety Valves: Automatic pressure relief.
 - j. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
 - 1) Casing: Radially split, cast iron.
 - 2) Pressure Rating: **[125 psig (860 kPa)][150 psig (1035 kPa)]** minimum.
 - 3) Impeller: ASTM B584 cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
 - 4) Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
 - 5) Seal: Mechanical.
 - 6) Motor: Open, dripproof motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 - k. Controls: Automatic control of circulating pump and tank backwash; factory wired for single electrical connection.
 - 1) Panel: NEMA 250, **[Type 4]<Insert type>** enclosure with time clock and pressure gages.
 - 2) Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
 - 3) Backwash: Automatic; with time clock and differential pressure switch.
 - 4) Backwash Valve: Tank mounted with valves interlocked to single actuator.
 - l. Support: Skid mounting. **[Fabricate supports, base, and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event, when filter base is anchored to building structure.]**
5. Capacities and Characteristics:
- a. Filter Design:
 - 1) Water Flow: **<Insert gpm (L/s)>**.
 - 2) Clean Pressure Loss: **[5 psig (34.5 kPa)]<Insert value>**.
 - 3) Maximum Media-Flow Rate: **[15 gpm/sq. ft. (10.2 L/s per sq. m)]<Insert value>**.

- 4) Filtration Efficiency: [98]<Insert number> percent.
 - 5) Particle-Specific Gravity: [1.8]<Insert number>.
 - 6) Particle Size: [5][10][20][45]<Insert number> microns.
- b. Filter Tank: With internal distribution piping.
- 1) Pressure Rating: <Insert psig (kPa)>.
 - 2) Diameter: <Insert inches (mm)>.
 - 3) Inlet and Outlet Size: <Insert NPS (DN)>.
 - 4) Blowdown Piping Outlet Size: <Insert NPS (DN)>.
- c. Filter Media: <Insert material>.
- d. Start Backwash Pressure Loss: [13 psig (90 kPa)]<Insert value>.
- e. Backwash Period: [10]<Insert number> minutes.
- f. Circulating Pump:
- 1) Capacity: <Insert gpm (L/s)>.
 - 2) Total Dynamic Head: <Insert feet (kPa)>.
 - 3) Motor Speed: <Insert number> rpm.
 - 4) Inlet Size: <Insert NPS (DN)>.
 - 5) Outlet Size: <Insert NPS (DN)>.
- g. Pump Motor Size and Electrical Characteristics:
- 1) Horsepower: <Insert value>.
 - 2) Volts: [120][208][240][277][480]<Insert number> V.
 - 3) Phase: [Single][Three].
 - 4) Hertz: [60]<Insert number> Hz.
- h. Unit Electrical Characteristics:
- 1) Full-Load Amperes: <Insert value>.
 - 2) Minimum Circuit Ampacity: <Insert value>.
 - 3) Maximum Overcurrent Protection: <Insert amperage>.
 - 4) Interrupting Capacity: <Insert amperage>.
- B. Self-Cleaning Strainers:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Everfilt]
 - b. [Hayward Flow Control; Hayward Industries, Inc.]
 - c. [Islip Flow Controls Inc.]
 - d. [Orival, Inc.]
 - e. [Sure Flow Equipment Inc]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Everfilt]

- b. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - c. **[Islip Flow Controls Inc.]**
 - d. **[Orival, Inc.]**
 - e. **[Sure Flow Equipment Inc]**
 - f. **<Insert manufacturer's name>**
3. Description: Factory-fabricated and -tested, ASTM A126, Class B, cast-iron or steel, self-cleaning strainer system of tank, strainer, backwash arm or cleaning spiral, drive and motor, piping, and controls for removing particles from water.
- a. Fabricate and label ASTM A126, Class B, cast-iron or steel strainer tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. Pipe Connections:
 - 1) NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606.
4. Motorized Valves: Flanged or grooved-end, ductile-iron angle type with **[EPDM]<Insert material>** valve seat and stem seal; with ASTM B148 aluminum bronze disc.
5. Strainer: ASTM A666, Type 316 stainless steel.
6. Piping: ASTM A53/A53M; Type S, F, or E; Grade B; Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding or ductile-iron fittings.
7. Safety Valves: Automatic pressure relief.
8. Backwash Arm Drive:
- a. Drive Casing: Cast iron.
 - b. Worm Gears: Immersed in oil.
 - c. Motor: Open, dripproof motor supported on the strainer-bearing frame. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
9. Controls: Automatic control of backwash; factory wired for single electrical connection.
- a. Panel: NEMA 250, **[Type 4]<Insert type>** enclosure with time clock and pressure gages.
 - b. Backwash Arm Drive: Automatic and manual switching; manual switch position bypasses safeties and controls.
 - c. Backwash: Automatic; with time clock and differential pressure switch.
 - d. Backwash Valve: Electric actuator.
10. Support: Skid mounting. **[Fabricate supports, base, and attachment to tank with reinforcement strong enough to resist strainer movement during a seismic event, when strainer base is anchored to building structure.]**
11. Capacities and Characteristics:
- a. Strainer Design:
 - 1) Water Flow: **<Insert gpm (L/s)>**.
 - 2) Clean Pressure Loss: **[5 psig (34.5 kPa)]<Insert value>**.
 - 3) Strainer Mesh: **[40][60][80]<Insert number>**.
 - b. Strainer Tank: With internal distribution piping.
 - 1) Material: **[Cast iron][Steel]<Insert material>**.
 - 2) Pressure Rating: **[150 psig (1034 kPa)]<Insert value>**.
 - 3) Inlet and Outlet Size: **<Insert NPS (DN)>**.

- 4) Backwash Piping Outlet Size: **<Insert NPS (DN)>**.
- c. Start Backwash: **[10 psig (69 kPa)]<Insert value>**.
- d. Backwash Period: **[5]<Insert number>** minutes.
- e. Drive Motor Size and Electrical Characteristics:
 - 1) Horsepower: **<Insert value>**.
 - 2) Volts: **[120][208][240][277][480]<Insert number>** V.
 - 3) Phase: **[Single][Three]**.
 - 4) Hertz: **[60]<Insert number>** Hz.
- f. Unit Electrical Characteristics:
 - 1) Full-Load Amperes: **<Insert value>**.
 - 2) Minimum Circuit Ampacity: **<Insert value>**.
 - 3) Maximum Overcurrent Protection: **<Insert amperage>**.
 - 4) Interrupting Capacity: **<Insert amperage>**.

C. Bag- or Cartridge-Type Filters:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eden Equipment Company]**
 - b. **[Filtration Systems; Mechanical Mfg. Corporation]**
 - c. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - d. **[Parker Hannifin Corp.; Process Filtration Div]**
 - e. **[Pentair, Inc.]**
 - f. **[PEP Filters, Inc.]**
 - g. **[Rosedale Products, Inc.]**
 - h. **[Shelco Filters]**
 - i. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eden Equipment Company]**
 - b. **[Filtration Systems; Mechanical Mfg. Corporation]**
 - c. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - d. **[Parker Hannifin Corp.; Process Filtration Div]**
 - e. **[Pentair, Inc.]**
 - f. **[PEP Filters, Inc.]**
 - g. **[Rosedale Products, Inc.]**
 - h. **[Shelco Filters]**
 - i. **<Insert manufacturer's name>**
- 3. Description: **[Floor-mounted housing][Housing]** with filter **[bags][cartridges]** for removing particles from water.
 - a. Housing: Corrosion resistant; designed to separate inlet from outlet and to direct inlet through **[bag][cartridge]**-type water filter; with **[bag support and]**base, feet, or skirt.

- 1) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - 2) Steel Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606.
 - 3) Plastic Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: **150-psig (1035-kPa)** plastic flanges.
- b. Bag or Cartridge, Replaceable: Of shape to fit housing.
4. Capacities and Characteristics:
- a. Filter Design:
 - 1) Water-Flow Rate: **<Insert gpm (L/s)>**.
 - 2) Filtration Efficiency: **[98]<Insert number>** percent.
 - 3) Particle Size: **[10][20]<Insert number>** microns and larger.
 - 4) Clean Pressure Loss: **[2 psig (14 kPa)]<Insert value>**.
 - 5) Pressure Loss at Replacement: **[6 psig (41 kPa)]<Insert value>**.
 - b. Housing:
 - 1) Material: **[Carbon steel][Plastic]**.
 - 2) Pressure Rating: **<Insert psig (kPa)>**.
 - 3) Seal Material: **[Nitrile rubber]<Insert material>**.
 - 4) Diameter: **<Insert inches (mm)>**.
 - 5) Height or Length: **<Insert inches (mm)>**.
 - 6) Inlet and Outlet Size: **<Insert NPS (DN)>**.
 - 7) Drain Size: **[Not applicable]<Insert NPS (DN)>**.
 - 8) Bag Support Basket Material: **[Stainless steel]<Insert material>**.
 - c. Bag or Cartridge:
 - 1) Number Required: **<Insert number>**.
 - 2) Nominal Diameter: **<Insert inches (mm)>**.
 - 3) Nominal Length: **<Insert inches (mm)>**.
 - 4) Media Material: **[Cotton][Polyester][Polypropylene]<Insert material>**.
- D. Centrifugal Separators:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Culligan International Company]**
 - b. **[Griswold Water Systems]**
 - c. **[LAKOS Filtration Solutions]**
 - d. **[PEP Filters, Inc.]**
 - e. **[Puroflux Corporation]**
 - f. **[Rosedale Products, Inc.]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Culligan International Company]
 - b. [Griswold Water Systems]
 - c. [LAKOS Filtration Solutions]
 - d. [PEP Filters, Inc.]
 - e. [Puroflux Corporation]
 - f. [Rosedale Products, Inc.]
 - g. <Insert manufacturer's name>
3. Description: Simplex separator housing, with baffles and chambers for removing particles from water by centrifugal action and gravity.
4. Housing: With manufacturer's proprietary system of baffles and chambers.
 - a. Construction: Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
 - c. Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.
 - d. Collection Chamber: Designed to hold separated particles.
 - e. Outlet: Near top of unit.
 - f. Purge: At bottom of collection chamber.
 - g. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - h. Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606. Provide stainless steel flanges if tank is stainless steel.
5. Motorized Purge Valve: Gate or plug pattern valve.
 - a. Motorized Valves: Butterfly-type, flanged or grooved-end, ductile-iron body, with [EPDM]<Insert material> valve seat and stem seal; with ASTM B148 aluminum bronze disc.
 - b. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Strainer: Stainless steel basket type mounted on pump suction.
7. Piping, Steel: ASTM A53/A53M; Type S, F, or E; Grade B; Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding or ductile-iron fittings.
8. Piping, Copper: **ASTM B88, Type L (ASTM B88M, Type B)** copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
9. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
 - a. Casing: Radially split, cast iron.
 - b. Pressure Rating: [125 psig (860 kPa)][150 psig (1035 kPa)] minimum.
 - c. Impeller: ASTM B584 cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
 - d. Shaft and Shaft Sleeve: Steel shaft with copper-alloy shaft sleeve.
 - e. Seal: Mechanical.
 - f. Motor: Open, dripproof motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 - g. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
10. Controls: Automatic control of circulating pump and separator purge; factory wired for single electrical connection.

- a. Panel: NEMA 250, **[Type 4]<Insert type>** enclosure.
 - b. Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
 - c. Separator Purge: Automatic and manual.
 - d. TSS Controller Interlock: Open separator purge valve with bleed-off control.
11. Support: Skid mounting. **[Fabricate supports, base, and attachment to separator housing with reinforcement strong enough to resist separator movement during a seismic event, when separator base is anchored to building structure.]**
12. Capacities and Characteristics:
- a. Separator Design:
 - 1) Water-Flow Rate: **<Insert gpm (L/s)>**.
 - 2) Pressure Loss: **[5 psig (34.5 kPa)]<Insert value>**.
 - 3) Separator Efficiency: **[98]<Insert number>** percent.
 - 4) Particle-Specific Gravity: **[1.8]<Insert number>**.
 - 5) Particle Size: **[5][10][20][45]<Insert number>** microns.
 - b. Housing:
 - 1) Material: **[Steel][Stainless steel][Plastic][Fiberglass]<Insert material>**.
 - 2) Pressure Rating: **<Insert psig (kPa)>**.
 - 3) Diameter: **<Insert inches (mm)>**.
 - 4) Height: **<Insert inches (mm)>**.
 - 5) Inlet and Outlet Size: **<Insert NPS (DN)>**.
 - 6) Purge Size: **<Insert NPS (DN)>**.
 - c. Circulating Pump:
 - 1) Capacity: **<Insert gpm (L/s)>**.
 - 2) Total Dynamic Head: **<Insert feet (kPa)>**.
 - 3) Motor Speed: **<Insert number>** rpm.
 - 4) Inlet Size: **<Insert NPS (DN)>**.
 - 5) Outlet Size: **<Insert NPS (DN)>**.
 - d. Pump Motor Size and Electrical Characteristics:
 - 1) Horsepower: **<Insert value>**.
 - 2) Volts: **[120][208][240][277][480]<Insert number>** V.
 - 3) Phase: **[Single][Three]**.
 - 4) Hertz: **[60]<Insert number>** Hz.
 - 5) Full-Load Amperes: **<Insert value>**.
 - 6) Minimum Circuit Ampacity: **<Insert value>**.
 - 7) Maximum Overcurrent Protection: **<Insert amperage>**.
 - 8) Interrupting Capacity: **<Insert amperage>**.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

- A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate. Install all chemical application equipment within a spill-containment area without floor drains.
- B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install water-testing equipment on wall near water-chemical-application equipment.
- D. Install interconnecting control wiring for chemical-treatment controls and sensors.
- E. Mount sensors and injectors in piping circuits.
- F. Bypass Feeders: Install in closed hydronic systems, including[**hot-water heating**],[**chilled water**],[**dual-temperature water**],[**glycol heating**],[and][**glycol cooling**], and equip with the following:
 - 1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 2. Install water meter in makeup-water supply.
 - 3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
 - 5. Install a swing check on inlet after the isolation valve.
- G. Install automatic fluid make-up equipment for glycol water system and include the following:
 - 1. Chemical solution tanks.
 - 2. Chemical solution injection pumps.
 - 3. Water meter in makeup supply to system.
 - 4. Pressure switch to operate injection pump as necessary to maintain glycol system pressure.
- H. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:
 - 1. Install makeup-water softener.
 - 2. Install water meter in makeup-water supply.
 - 3. Install inhibitor injection pumps and solution tanks with injection-timer-sensing contacts in water meter.
 - a. Pumps shall operate for timed interval when contacts close at water meter in makeup-water supply connection.
 - 4. Install test equipment and furnish test-kit to Owner.
 - 5. Install RO unit for makeup water.
 - 6. Install TDS controller with sensor and bleed valves.
 - a. Bleed valves to cycle, to maintain maximum TDS concentration.
 - 7. Install TSS controller with sensor and bleed valves.

- a. Bleed valves to cycle, to maintain maximum TSS concentration.
- 8. Install inhibitor injection timer with injection pumps and solution tanks.
 - a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into main steam supply header.
- I. Install automatic chemical-feed equipment for open [**condenser**][**fluid-cooler spray**] water and include the following:
 - 1. Install water meter in makeup-water supply.
 - 2. Install inhibitor injection pumps and solution tanks with injection-timer-sensing contacts in water meter.
 - a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
 - 3. Install test equipment, and provide test-kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 4. Install TDS controller with sensor and bleed valves.
 - a. Bleed valves to cycle, to maintain maximum TDS concentration.
 - 5. Install TSS controller with sensor and bleed valves.
 - a. Bleed valves to cycle, to maintain maximum TSS concentration.
 - 6. Install pH sensor and controller with injection pumps and solution tanks.
 - a. Injector pumps shall operate to maintain required pH.
 - 7. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.
 - a. Injection pumps shall operate to feed biocide on an alternating basis.
 - 8. Install ozone generator with diffusers in condenser-water piping.
 - a. Ozone generator shall operate continuously with condenser-water flow.
 - 9. Install UV-irradiation lamps in condenser-water piping.
 - a. UV lights shall operate continuously with condenser-water flow.

3.3 INSTALLATION OF OZONE GENERATOR

- A. Install ozone generator and equipment on concrete bases level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
- B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Pipe ozone from ozone generator to condenser water with stainless steel pipe and fittings with welded

joints.

- D. Install **[two][three]**-piece, stainless steel ball valve in ozone supply to condenser water.
- E. Pipe cooling water to ozone generator and to air-gap drain fitting with stainless steel pipe and fittings with welded joints where enclosed in ozone-generator room.
- F. Install **[two][three]**-piece, stainless steel ball valve in cooling water supply to ozone generator.
- G. Mounting supports for ozone generator shall be ASTM A666, Type 316 stainless steel.
- H. Mount breathing apparatus outside ozone-generator room.
- I. Mount and install ozone detector, warning lights, and audible alarm inside ozone-generator room. Mount another set of warning lights and audible alarm just outside the main entrance to ozone-generator room.

3.4 INSTALLATION OF UV-IRRADIATION UNIT

- A. Install UV-irradiation units on concrete bases level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
- B. Install seismic restraints for UV-irradiation units and floor-mounting accessories, and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

3.5 INSTALLATION OF WATER SOFTENER

- A. Install water softener equipment on concrete bases level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
- B. Install seismic restraints for tanks and floor-mounting accessories, and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.
- D. Prepare mineral-tank distribution system and underbed for minerals, and place specified mineral into mineral tanks.
- E. Install water-testing sets on wall adjacent to water softeners.

3.6 INSTALLATION OF RO UNIT

- A. Install RO unit and storage tank on concrete bases level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor RO unit and storage tank with pumps to substrate.
- B. Install seismic restraints for tanks and floor-mounting accessories, and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install interconnecting piping and controls furnished by equipment manufacturer but not factory installed.

- D. Install water-testing sets on wall adjacent to RO unit.

3.7 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.
- C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."
- D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 "General-Duty Valves for HVAC Piping."
- E. See Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

3.8 ELECTRICAL CONNECTIONS

- A. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.9 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation, and calibrate controls during the preliminary phase of HVAC system's startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.



6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of **50 psig (345 kPa)** above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials, and retest piping until no leaks exist.

E. Equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report, advising Owner of changes necessary to adhere to "Performance Requirements" Article for each required characteristic. Sample boiler water at **[four][six][eight]<Insert number>**-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.

H. At **[four][six][eight]<Insert number>**-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis, advising Owner of changes necessary to adhere to "Performance Requirements" Article.

I. Comply with ASTM D3370 and with the following standards:

1. Silica: ASTM D859.
2. Steam System: ASTM D1066.
3. Acidity and Alkalinity: ASTM D1067.
4. Iron: ASTM D1068.
5. Water Hardness: ASTM D1126.

3.10 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion, scale formation, and biological growth for **[cooling, chilled-water piping][heating, hot-water piping][heating, steam and condensate piping][steam and condensate system for humidifier and cooking appliance applications][condenser-water piping]** and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.11 DEMONSTRATION

A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

- B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment. When training is complete, turn over video to Owner for future use.

END OF SECTION 23 25 00 00



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 25 00 00A - WATER TREATMENT FOR OPEN-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water treatment for open-loop hydronic systems.
2. Automatic chemical-feed equipment.
3. Ozone-generator biocide equipment.
4. Stainless steel pipes and fittings.
5. UV biocide equipment.
6. Chemical-treatment test equipment.
7. Chemicals.
8. TDS controllers.
9. TSS controllers.

B. Related Requirements:

1. Section 232533 "HVAC Makeup-Water Filtration Equipment" for water treatment of water softeners, RO equipment, and filtration equipment.

1.2 DEFINITIONS

- A. EEPROM: Electrically erasable, programmable read-only memory.
- B. PPM: Parts per million.
- C. RO: Reverse osmosis.
- D. TDS: Total dissolved solids consist of salts and other materials that combine with water as a solution.
- E. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Water meters.
2. Inhibitor injection timers.
3. pH controllers.
4. TDS controllers.
5. Biocide feeder timers.
6. Chemical solution tanks.
7. Injection pumps.
8. Ozone generators.
9. UV-irradiation units.

10. Chemical-treatment test equipment.
11. Chemical material safety data sheets.

- B. Shop Drawings: Pretreatment equipment and chemical- **[and ozone-generator-biocide-][and UV-irradiation-biocide-]**treatment equipment, showing tanks, maintenance space required, and piping connections to HVAC systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- C. Field quality-control reports.
- D. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
- E. Water Analysis: Illustrate water quality available at Project site.
- F. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 WATER TREATMENT FOR OPEN-LOOP HYDRONIC SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Anderson Chemical Company]**
2. **[Aqua-Chem, Inc.]**
3. **[Barclay Water Management, Inc]**
4. **[Boland Trane Services]**
5. **[Cascade Water Services, Inc]**
6. **[Earthwise Environmental Inc]**
7. **[H-O-H Water Technology, Inc]**
8. **[Metro Group, Inc. (The)]**
9. **[Nalco; an Ecolab company]**
10. **[Suez Water Technologies (Formerly GE Water)]**
11. **[Watcon, Inc]**
12. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Anderson Chemical Company]**
2. **[Aqua-Chem, Inc.]**
3. **[Barclay Water Management, Inc]**
4. **[Boland Trane Services]**
5. **[Cascade Water Services, Inc]**
6. **[Earthwise Environmental Inc]**
7. **[H-O-H Water Technology, Inc]**
8. **[Metro Group, Inc. (The)]**
9. **[Nalco; an Ecolab company]**
10. **[Suez Water Technologies (Formerly GE Water)]**
11. **[Watcon, Inc]**
12. **<Insert manufacturer's name>**

2.2 PERFORMANCE REQUIREMENTS

- A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems, as indicated in this Specification. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C. Open hydronic systems, including **[condenser][and][fluid-cooler spray]** water, shall have the following water qualities:
1. pH: Maintain a value within **<Insert range>**.
 2. Alkalinity: Maintain a maximum value of **<Insert range>** mg/L as CaCO₃.
 3. Silica in Cooling Towers: Maintain a value no higher than **<Insert number>** mg/L.

4. Silica in Evaporative Condensers: Maintain a value no higher than **<Insert number> mg/L**.
5. Hardness in Cooling Towers: Maintain a value no higher than **<Insert value> mg/L as CaCO₃**.
6. Hardness in Evaporative Condensers: Maintain a value no higher than **<Insert value> mg/L as CaCO₃**.
7. Steel Corrosion Inhibitors: Provide sufficient inhibitors to limit mild steel corrosion to **<Insert number> mils per year**. Maintain soluble iron concentrations at or below **<Insert value> mg/L**.
8. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to **<Insert number> mils per year**. Maintain soluble copper concentrations at or below **<Insert value> mg/L**.
9. Scale Control: **[Provide softened water for initial fill and makeup.][Provide sufficient scale inhibitors to prevent formation of scale, and maintain all scale-forming material in solution.]**
10. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
11. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of **<Insert number> organisms/mL**.
 - b. Total Anaerobic Plate Count: Maintain a maximum value of **<Insert number> organisms/mL**.
 - c. Nitrate Reducers: Maintain a maximum value of **<Insert number> organisms/mL**.
 - d. Sulfate Reducers: Maintain a maximum value of **<Insert number> organisms/mL**.
 - e. Iron Bacteria: Maintain a maximum value of **<Insert number> organisms/mL**.
12. **<Insert other applicable requirements>**.

D. Passivation for Galvanized Steel:

1. Passivation of all galvanized-steel cooling towers and other system components must be conducted strictly in accordance with manufacturer's instructions in order to validate warranties. During the required passivation period, all water-quality parameters must be maintained in accordance with manufacturer's specifications, and all other requirements must be observed.

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter, Oscillating Piston:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: **150 psig (1035 kPa)**.
4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
5. Registration: **Gallons (Liters) or cubic feet (cubic meters)**.
6. End Connections: Threaded.
7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**

B. Water Meter, Turbine Type, Threaded:

1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: **100 psig (690 kPa)**.

4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
5. Registration: **Gallons (Liters)** or **cubic feet (cubic meters)**.
6. End Connections: Threaded.
7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
8. **[Electronic or digital interface for flowrate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**

C. Water Meter, Turbine Type, Flanged:

1. AWWA C701, turbine-type, totalization meter.
2. Body: **[Bronze][Epoxy-coated cast iron]**.
3. Minimum Working-Pressure Rating: **150 psig (1035 kPa)**.
4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
5. Registration: **Gallons (Liters)** or **cubic feet (cubic meters)**.
6. End Connections: Flanged.
7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**

D. Inhibitor Injection Timers:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]**
2. Programmable timers, with infinite adjustment over full range, mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. Digital display makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. pH Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]**
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High- or low-pH-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.

7. Internal adjustable hysteresis or deadband.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. TDS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]**
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves:
 - a. Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.

G. TSS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from 0.001 mg/L to 50 g/L. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 4X enclosure. **[Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]**
2. **[Forms of Digital Communication:][MODBUS RS-232][MODBUS RS-485][Profibus DP].**
3. Digital display and touch pad for input.
4. Sensor probe adaptable to sample stream manifold.
5. High- or low-value-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.

H. Biocide Feeder Timer:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]**
2. 24-hour timer with 14-day skip feature to permit activation any hour of day.
3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
4. Solid-state alternator to enable use of two different formulations.
5. 24-hour display of time of day.
6. 14-day display of day of week.
7. Battery backup, so clock is not disturbed by power outages.
8. Hand-off-auto switches for biocide pumps.
9. Biocide A and Biocide B pump running indication.

I. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: [30 gal. (114 L)][50 gal. (189 L)][120 gal. (454 L)]<Insert value>.

J. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230500 "Common Work Results for HVAC."
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

K. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints, except ASTM A269/A269M, Type 304 stainless steel for steam boiler injection assemblies.

L. Injection Assembly:

1. Quill: Minimum **NPS 1/2 (DN 15)** with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: [**Three**][**Two**]-piece stainless steel, as described in "Stainless Steel Pipes and Fittings" Article; selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum **600 psig (4137 kPa)** at **200 deg F (93 deg C)**.

2.4 OZONE-GENERATOR BIOCIDES EQUIPMENT

- A. Corona discharge generator with stainless steel generating cells, and transformer housed in a NEMA 250, Type 4 enclosure. Assembly shall be suitable for continuous duty. Include factory-mounted site glasses to verify proper operation of generator.
- B. Water-cooled generators shall be provided with cooling water at maximum [**70 deg F (21 deg C)**]<Insert value> and [**35 psig (241 kPa)**]<Insert value>.
- C. Generator vessels shall be constructed in accordance with 2017 ASME Boiler and Pressure Vessel Code, bear an ASME label, and be equipped with pressure relief valve.
- D. External air compressor or induced airflow through a cleanable prefilter shall supply concentrated oxygen through a molecular sieve, with **minus 62 deg F (minus 52 deg C)** dew point to avoid the formation of nitric acid.
- E. Controls: Microprocessor based with software in EEPROM, surge protection, high-temperature cutout, and operational status lights.[**Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."**]
- F. Ozone Contactors:
 1. Bubble diffusers.
 2. Induction injection nozzle.

3. Injectors with static mixers.
- G. Ozone Detector and Alarm Devices:
1. Detector:
 - a. Sensor: Metal dioxide semiconductor.
 - b. Concentration Range: **[0 to 10]<Insert range>** ppm.
 - c. Accuracy: Plus or minus 0.01 ppm.
 - d. Sensitivity: 0.01 ppm.
 - e. Response Time: Maximum 10 seconds.
 - f. Operating Temperature: **50 to 100 deg F (10 to 38 deg C)**.
 - g. Relative Humidity: 15 to 90 percent, noncondensing over the operating temperature range.
 2. Horns:
 - a. Electric-vibrating-polarized type.
 - b. 24-V dc, with provision for housing the operating mechanism behind a grille.
 - c. Horns shall produce a sound-pressure level of 90 dBA, measured **10 feet (3 m)** from the horn.
 - d. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 3. Visible Alarm Devices:
 - a. Xenon strobe lights listed in UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate.
 - b. Rated Light Output: **[75][110]<Insert number>** candela.
 - c. Strobe Leads: Factory connected to screw terminals.
 - d. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- H. Self-Contained Breathing Apparatus: Open-circuit, pressure-demand, compressed air includes completely assembled, portable, self-contained devices designed for hazardous breathing environment application.
1. Face Piece: EPDM or silicone rubber construction material, one-size-fits-all with double-sealing edge, stainless steel speaking diaphragm and lens retainer, five adjustable straps to hold face piece to head (two straps on each side and one on top), exhalation valve in mask, close-fitting nose piece to ensure no CO(2) buildup, and perspiration drain to avoid skin irritation and to prevent eyepiece, spectacle, and lens fogging.
 2. Backplate: Orthopedically designed of **[chemical and impact-resistant, glass-fiber composite][aluminum]**.
 3. Harness and Carrier Assembly: Large triangular back pad, backplate, and adjustable waist and shoulder straps; modular in design, detachable components, and easy to clean and maintain. Shoulder straps are padded with flame-resistant material, reinforced with stainless steel cable, and attached with T-nuts, washers, and screws.
 4. Air Cylinder: **[30][45][60]**-minute, low-pressure, air-supply-loaded **[fiberglass][aluminum][steel]** cylinders fitted with quick-fill assembly for refilling and air transfer.
 5. Wall-Mounting Cabinet: Leakproof, corrosion-resistant, clear, plastic case.
 6. Tested and Certified: By the National Institute for Occupational Safety and Health and by the Mine Safety and Health Administration, in accordance with 42 CFR 84, Subpart H.

2.5 STAINLESS STEEL PIPES AND FITTINGS

- A. Stainless Steel Tubing: Comply with ASTM A269/A269M, Type 316.
- B. Stainless Steel Fittings: Comply with ASTM A815/A815M, Type 316, Grade WP-S.
- C. Two-Piece, Full-Port, Stainless Steel Ball Valves: ASTM A351/A351M, Type 316 stainless steel body; ASTM A276/A276M, Type 316 stainless steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and **250-psig (1725-kPa)** steam working-pressure rating and **600-psig (4140-kPa)** cold working-pressure rating.
- D. Three-Piece, Full-Port, Stainless Steel Ball Valves: ASTM A351/A351M, Type 316 stainless steel body; ASTM A276/A276M, Type 316 stainless steel stem and vented ball, threaded body design with adjustable stem packing, threaded ends, and **150-psig (1035-kPa)** steam working pressure and **600-psig (4140-kPa)** cold working pressure rating.

2.6 UV BIOCIDES EQUIPMENT

- A. Target Irradiation: Minimum 30 mJ x s/sq. cm.
- B. Light Source Vessels:
 - 1. ASTM A666, Type 304 stainless steel.
 - 2. Construct for minimum [**150 psig (1035 kPa)**]**<Insert value>** at [**150 deg F (65 deg C)**]**<Insert value>** in accordance with 2017 ASME Boiler and Pressure Vessel Code, and equip with pressure-relief valve.
 - 3. Light Source Sleeve: Quartz, with EPDM O-ring seals.
 - 4. Light Source: Replaceable UV lamp producing a minimum target irradiation of 254-nm wavelength light.
- C. Controls: Interlock with pumps to operate when water is circulating.

2.7 CHEMICAL-TREATMENT TEST EQUIPMENT

- A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounted cabinet for testing pH, TSS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.
- B. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
 - 1. [**Four**]**<Insert number>**-station rack for open systems.

2.8 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer, compatible with piping system components and connected equipment, and able to attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

- A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate. Install all chemical application equipment within a spill-containment area without floor drains.
- B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install water-testing equipment on wall near water-chemical-application equipment.
- D. Install interconnecting control wiring for chemical-treatment controls and sensors.
- E. Mount sensors and injectors in piping circuits.
- F. Install automatic chemical-feed equipment for open [**condenser**][**fluid-cooler spray**] water, and include the following:
 - 1. Install water meter in makeup-water supply.
 - 2. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
 - a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection.
 - 3. Install test equipment and provide test kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 4. Install TDS controller with sensor and bleed valves.
 - a. Bleed valves to cycle, to maintain maximum TDS concentration.
 - 5. Install TSS controller with sensor and bleed valves.
 - a. Bleed valves to cycle, to maintain maximum TSS concentration.
 - 6. Install pH sensor and controller with injection pumps and solution tanks.
 - a. Injector pumps shall operate to maintain required pH.
 - 7. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.
 - a. Injection pumps shall operate to feed biocide on an alternating basis.
 - 8. Install ozone generator with diffusers in condenser-water piping.

- a. Ozone generator shall operate continuously with condenser-water flow.
- 9. Install UV-irradiation lamps in condenser-water piping.
 - a. UV lights shall operate continuously with condenser-water flow.

3.3 INSTALLATION OF OZONE GENERATOR

- A. Install ozone generator and equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
- B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Pipe ozone from ozone generator to condenser water with stainless steel pipe and fittings with welded joints.
- D. Install ~~[two]~~**[three]**-piece, stainless steel ball valve in ozone supply to condenser water.
- E. Pipe cooling water to ozone generator and to air-gap drain fitting with stainless steel pipe and fittings with welded joints where enclosed in ozone-generator room.
- F. Install ~~[two]~~**[three]**-piece, stainless steel ball valve in cooling water supply to ozone generator.
- G. Mounting supports for ozone generator shall be ASTM A666, Type 316 stainless steel.
- H. Mount breathing apparatus outside ozone-generator room.
- I. Mount and install ozone detector, warning lights, and audible alarm inside ozone-generator room. Mount another set of warning lights and audible alarm just outside the main entrance to ozone-generator room.

3.4 INSTALLATION OF UV-IRRADIATION UNIT

- A. Install UV-irradiation units on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
- B. Install seismic restraints for UV-irradiation units and floor-mounting accessories, and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

3.5 PIPING CONNECTIONS

- A. Where installing piping adjacent to equipment, allow space for service and maintenance.
- B. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for dielectric fittings.
- C. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate

Valves for HVAC Piping."

- D. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.
- E. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

3.6 ELECTRICAL CONNECTIONS

- A. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.7 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation, and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 - 7. Cap and subject piping to static water pressure of **50 psig (345 kPa)** above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 - 8. Repair leaks and defects with new materials, and retest piping until no leaks exist.
- C. Equipment will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. At **[four][six][eight]<Insert number>**-week intervals following Substantial Completion, perform separate water analyses on HVAC systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis, advising Owner of changes necessary to adhere to "Performance Requirements" Article.

F. Comply with ASTM D3370 and with the following standards:

1. Silica: ASTM D859.
2. Acidity and Alkalinity: ASTM D1067.
3. Iron: ASTM D1068.
4. Water Hardness: ASTM D1126.

3.8 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion, scale formation, and biological growth for **[condenser-water piping]** and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and hydronic water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.
- B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 23 25 00 00A



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 25 00 00B - WATER TREATMENT FOR STEAM SYSTEM FEEDWATER

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water treatment for steam system feedwater.
2. Automatic chemical-feed equipment.
3. Stainless steel pipes and fittings.
4. Chemical-treatment test equipment.
5. Chemicals.

B. Related Requirements:

1. Section 232533 "HVAC Makeup-Water Filtration Equipment" for water treatment of water softeners, RO equipment, and filtration equipment.

1.2 DEFINITIONS

- A. RO:** Reverse osmosis.
- B. TDS:** Total dissolved solids.
- C. TSS:** Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Water meters.
2. Inhibitor injection timers.
3. pH controllers.
4. TDS controllers.
5. TSS controllers.
6. Chemical solution tanks.
7. Injection pumps.
8. Chemical-treatment test equipment.
9. Chemical material safety data sheets.

B. Shop Drawings: Pretreatment and chemical-treatment equipment, showing tanks, maintenance space required, and piping connections to steam systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.



1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- C. Field quality-control reports.
- D. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
- E. Water Analysis: Illustrate water quality available at Project site.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Steam System Water-Treatment Service Provider Qualifications: An experienced steam system water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 WATER TREATMENT FOR STEAM SYSTEM FEEDWATER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[Anderson Chemical Company]**
 - 2. **[Aqua-Chem, Inc.]**
 - 3. **[Barclay Water Management, Inc]**
 - 4. **[Boland Trane Services]**
 - 5. **[Cascade Water Services, Inc]**
 - 6. **[Earthwise Environmental Inc]**
 - 7. **[H-O-H Water Technology, Inc]**
 - 8. **[Metro Group, Inc. (The)]**
 - 9. **[Nalco; an Ecolab company]**
 - 10. **[Suez Water Technologies (Formerly GE Water)]**

11. [Watcon, Inc]
12. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Anderson Chemical Company]
2. [Aqua-Chem, Inc.]
3. [Barclay Water Management, Inc]
4. [Boland Trane Services]
5. [Cascade Water Services, Inc]
6. [Earthwise Environmental Inc]
7. [H-O-H Water Technology, Inc]
8. [Metro Group, Inc. (The)]
9. [Nalco; an Ecolab company]
10. [Suez Water Technologies (Formerly GE Water)]
11. [Watcon, Inc]
12. <Insert manufacturer's name>

2.2 PERFORMANCE REQUIREMENTS

- A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems, as indicated in this Specification. Water quality for steam systems shall minimize corrosion and scale buildup for optimum efficiency of steam and condensate equipment without creating a hazard to operating personnel or the environment.
- B. Base steam system feedwater treatment on quality of water available at Project site, steam and condensate system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

1. Steam Condensate:
 - a. pH: Maintain a value within <Insert range>.
 - b. Alkalinity: Maintain a value no higher than <Insert range> mg/L as CaCO₃.
 - c. Steel Corrosion Inhibitors: Provide sufficient inhibitors to limit mild steel corrosion to <Insert number> mils per year. Maintain soluble iron concentrations at or below <Insert value> mg/L.
 - d. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to <Insert value> mils per year. Maintain soluble copper concentrations at or below <Insert value> mg/L.
 - e. Ammonia: Maintain a value of <Insert number> mg/L.
 - f. <Insert other requirements if necessary>.
2. Steam boiler operating at **100 psig (690 kPa)** and less shall have the following water qualities:
 - a. Silica: Maintain a value no higher than <Insert value> mg/L as SiO₂.
 - b. TSS: Maintain a value no higher than <Insert value> mg/L.
 - c. TDS: Maintain a value no higher than <Insert value> mg/L.
 - d. Total Alkalinity: Maintain a value no higher than <Insert value>mg/L as CaCO₃.
 - e. pH: Maintain a value within <Insert range> pH.
 - f. <Insert other applicable requirements>.

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter, Oscillating Piston:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: **150 psig (1035 kPa)**.
4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
5. Registration: **Gallons (Liters)** or **cubic feet (cubic meters)**.
6. End Connections: Threaded.
7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**

B. Inhibitor Injection Timers:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]**
2. Programmable timers with infinite adjustment over full range, mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. Digital display makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.

C. pH Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]**
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High or low-pH-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.

D. Water Meter, Turbine Type, Threaded:

1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: **100 psig (690 kPa)**.
4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
5. Registration: **Gallons (Liters)** or **cubic feet (cubic meters)**.
6. End Connections: Threaded.

7. [Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]
8. [Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]
9. [Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]

E. Water Meter, Turbine Type, Flanged:

1. AWWA C701, turbine-type, totalization meter.
2. Body: [Bronze][Epoxy-coated cast iron].
3. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
5. Registration: Gallons (Liters) or cubic feet (cubic meters).
6. End Connections: Flanged.
7. [Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will momentarily close at adjustable increments of total flow.]
8. [Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]
9. [Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]

F. TDS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. [Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves:

- a. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

G. TSS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from 0.001 mg/L to 50 g/L. Incorporate solid-state integrated circuits and digital display in NEMA 250 Type 4X enclosure. [Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]
2. [Forms of digital communication:][MODBUS RS-232][MODBUS RS-485][Profibus DP].
3. Digital display and touch pad for input.
4. Sensor probe adaptable to sample stream manifold.
5. High- or low-value-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.

H. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: [30 gal. (114 L)][50 gal. (189 L)][120 gal. (454 L)]<Insert value>.

I. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230500 "Common Work Results for HVAC."
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

J. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A269/A269M, Type 304 stainless steel for steam boiler injection assemblies.

K. Injection Assembly:

1. Quill: Minimum **NPS 1/2 (DN 15)** with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: [**Three**][**Two**]-piece stainless steel, as described in "Stainless Steel Pipes and Fittings" Article; selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum **600 psig (4137 kPa)** at **200 deg F (93 deg C)**.

2.4 STAINLESS STEEL PIPES AND FITTINGS

- A. Stainless Steel Tubing: Comply with ASTM A269/A269M, Type 316.
- B. Stainless Steel Fittings: Comply with ASTM A815/A815M, Type 316, Grade WP-S.
- C. Two-Piece, Full-Port, Stainless Steel Ball Valves: ASTM A351/A351M, Type 316 stainless steel body; ASTM A276/A276M, Type 316 stainless steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and **250-psig (1725-kPa)** steam working-pressure rating and **600-psig (4140-kPa)** cold working-pressure rating.
- D. Three-Piece, Full-Port, Stainless Steel Ball Valves: ASTM A351/A351M, Type 316 stainless steel body; ASTM A276/A276M, Type 316 stainless steel stem and vented ball, threaded body design with adjustable stem packing, threaded ends, and **150-psig (1035-kPa)** steam working-pressure rating and **600-psig (4140-kPa)** cold working-pressure rating.

2.5 CHEMICAL-TREATMENT TEST EQUIPMENT

- A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounted cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure

boilers, and oxidizing biocide test for open cooling systems.

B. Sample Cooler:

1. Tube: Sample.

- a. Size: **NPS 1/4 (DN 8)** tubing.
- b. Material: ASTM A666, Type 316 stainless steel.
- c. Pressure Rating: Minimum **2000 psig (13 790 kPa)**.
- d. Temperature Rating: Minimum **850 deg F (454 deg C)**.

2. Shell: Cooling water.

- a. Material: ASTM A666, Type 304 stainless steel.
- b. Pressure Rating: Minimum **250 psig (1725 kPa)**.
- c. Temperature Rating: Minimum **450 deg F (232 deg C)**.

3. Capacities and Characteristics:

a. Tube: Sample.

- 1) Flow Rate: **[0.25 gpm (0.016 L/s)]<Insert value>**.
- 2) Entering Temperature: **[400 deg F (204 deg C)]<Insert value>**.
- 3) Leaving Temperature: **[88 deg F (31 deg C)]<Insert value>**.
- 4) Pressure Loss: **[6.5 psig (44.8 kPa)]<Insert value>**.

b. Shell: Cooling water.

- 1) Flow Rate: **[3 gpm (0.19 L/s)]<Insert value>**.
- 2) Entering Temperature: **[70 deg F (21 deg C)]<Insert value>**.
- 3) Pressure Loss: **[1.0 psig (6.89 kPa)]<Insert value>**.

C. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.

- 1. **[Two]<Insert number>**-station rack for closed-loop systems.
- 2. **[Four]<Insert number>**-station rack for open-loop systems.

2.6 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

- A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate. Install all chemical application equipment within a spill-containment area without floor drains.
- B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install water-testing equipment on wall near water-chemical-application equipment.
- D. Install interconnecting control wiring for chemical-treatment controls and sensors.
- E. Mount sensors and injectors in piping circuits.
- F. Install automatic chemical-feed equipment for steam boiler and steam condensate systems, and include the following:
 - 1. Install makeup-water softener.
 - 2. Install water meter in makeup-water supply.
 - 3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
 - a. Pumps shall operate for timed interval when contacts close at water meter in makeup-water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
 - 4. Install test equipment and furnish test kit to Owner.
 - 5. Install RO unit for makeup water.
 - 6. Install TDS controller with sensor and bleed valves.
 - a. Bleed valves to cycle, to maintain maximum TDS concentration.
 - 7. Install TSS controller with sensor and bleed valves.
 - a. Bleed valves shall cycle, to maintain maximum TSS concentration.
 - 8. Install inhibitor injection timer with injection pumps and solution tanks.
 - a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into main steam supply header.
- G. Install automatic chemical-feed equipment for **[condenser][fluid-cooler spray]** water and include the following:
 - 1. Install water meter in makeup-water supply.
 - 2. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
 - a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.

3. Install test equipment and provide test kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
4. Install TSS controller with sensor and bleed valves.
 - a. Bleed valves shall cycle, to maintain maximum TSS concentration.
5. Install pH sensor and controller with injection pumps and solution tanks.
 - a. Injector pumps shall operate to maintain required pH.

3.3 PIPING CONNECTIONS

- A. Where installing piping adjacent to equipment, allow space for service and maintenance.
- B. Make piping connections between steam system water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232113 "Hydronic Piping" for dielectric fittings.
- C. Install shutoff valves on steam system water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."
- D. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.
- E. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

3.4 ELECTRICAL CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 3. Place steam system water-treatment system into operation and calibrate controls during the preliminary phase of steam system's startup procedures.
 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.

5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 7. Cap and subject piping to static water pressure of **50 psig (345 kPa)** above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 8. Repair leaks and defects with new materials, and retest piping until no leaks exist.
- C. Equipment will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising Owner of changes necessary to adhere to "Performance Requirements" Article for each required characteristic. Sample boiler water at **[four][six][eight]<Insert number>**-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.
- F. Comply with ASTM D3370 and with the following standards:
1. Silica: ASTM D859.
 2. Steam System: ASTM D1066.
 3. Acidity and Alkalinity: ASTM D1067.
 4. Iron: ASTM D1068.
 5. Water Hardness: ASTM D1126.

3.6 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion, scale formation, and biological growth for **[heating, steam and condensate piping][condenser-water piping]** and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:
1. Initial water analysis and steam system water-treatment recommendations.
 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 3. Periodic field service and consultation.
 4. Customer report charts and log sheets.
 5. Laboratory technical analysis.
 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.7 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain steam and condensate-treatment systems and equipment.
- B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

END OF SECTION 23 25 00 00B



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 25 00 00C - WATER TREATMENT FOR HUMIDIFICATION STEAM SYSTEM FEEDWATER

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water treatment for humidification steam system feedwater.
2. Automatic chemical-feed equipment.
3. Stainless steel pipes and fittings.
4. Chemical-treatment test equipment.
5. Chemicals.

B. Related Requirements:

1. Section 232533 "HVAC Makeup-Water Filtration Equipment" for water treatment of water softeners, RO equipment, and filtration equipment.

1.2 DEFINITIONS

- A. RO:** Reverse osmosis.
- B. TDS:** Total dissolved solids.
- C. TSS:** Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Water meters.
2. Inhibitor injection timers.
3. pH controllers.
4. TDS controllers.
5. TSS controllers.
6. Chemical solution tanks.
7. Injection pumps.
8. Chemical-treatment test equipment.
9. Chemical material safety data sheets.

B. Shop Drawings: Pretreatment equipment and chemical-treatment equipment, showing tanks, maintenance space required, and piping connections to humidification steam feedwater systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For equipment and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- C. Field quality-control reports.
- D. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
- E. Water Analysis: Illustrate water quality available at Project site.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Water-Treatment Humidification Steam System Feedwater Service Provider Qualifications: An experienced service provider of HVAC water treatment for humidification steam system feedwater, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 WATER TREATMENT FOR HUMIDIFICATION STEAM SYSTEM FEEDWATER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[Anderson Chemical Company]**
 - 2. **[Aqua-Chem, Inc.]**
 - 3. **[Barclay Water Management, Inc]**
 - 4. **[Boland Trane Services]**
 - 5. **[Cascade Water Services, Inc]**
 - 6. **[Earthwise Environmental Inc]**
 - 7. **[H-O-H Water Technology, Inc]**
 - 8. **[Metro Group, Inc. (The)]**

9. [Nalco; an Ecolab company]
10. [Suez Water Technologies (Formerly GE Water)]
11. [Watcon, Inc]
12. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Anderson Chemical Company]
2. [Aqua-Chem, Inc.]
3. [Barclay Water Management, Inc]
4. [Boland Trane Services]
5. [Cascade Water Services, Inc]
6. [Earthwise Environmental Inc]
7. [H-O-H Water Technology, Inc]
8. [Metro Group, Inc. (The)]
9. [Nalco; an Ecolab company]
10. [Suez Water Technologies (Formerly GE Water)]
11. [Watcon, Inc]
12. <Insert manufacturer's name>

2.2 PERFORMANCE REQUIREMENTS

- A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems, as indicated in this Specification. Water quality for humidification steam systems shall minimize corrosion and scale buildup for optimum efficiency of humidification steam equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, humidification steam system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

1. Steam Condensate:
 - a. pH: Maintain a value within <Insert range>.
 - b. Alkalinity: Maintain a value no higher than <Insert range> mg/L as CaCO(3).
 - c. Steel Corrosion Inhibitors: Provide sufficient inhibitors to limit mild steel corrosion to <Insert number> mils per year. Maintain soluble iron concentrations at or below <Insert value> mg/L.
 - d. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to <Insert value> mils per year. Maintain soluble copper concentrations at or below <Insert value> mg/L.
 - e. Ammonia: Maintain a value of <Insert number> mg/L.
 - f. <Insert other requirements if necessary>.
2. Steam boiler operating at 100 psig (690 kPa) and less shall have the following water qualities:
 - a. Silica: Maintain a value no higher than <Insert value> mg/L as SiO(2).
 - b. TSS: Maintain a value no higher than <Insert value> mg/L.
 - c. TDS: Maintain a value no higher than <Insert value> mg/L.
 - d. Total Alkalinity: Maintain a value no higher than <Insert value>mg/L as CaCO(3).
 - e. pH: Maintain a value within <Insert range> pH.
 - f. <Insert other applicable requirements>.

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter, Oscillating Piston:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: **150 psig (1035 kPa)**.
4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
5. Registration: **Gallons (Liters)** or **cubic feet (cubic meters)**.
6. End Connections: Threaded.
7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**

B. Water Meter, Turbine Type, Threaded:

1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: **100 psig (690 kPa)**.
4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
5. Registration: **Gallons (Liters)** or **cubic feet (cubic meters)**.
6. End Connections: Threaded.
7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**

C. Water Meter, Turbine Type, Flanged:

1. AWWA C701, turbine-type, totalization meter.
2. Body: **[Bronze][Epoxy-coated cast iron]**.
3. Minimum Working-Pressure Rating: **150 psig (1035 kPa)**.
4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
5. Registration: **Gallons (Liters)** or **cubic feet (cubic meters)**.
6. End Connections: Flanged.
7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**

D. TDS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure

with gasketed and lockable door. [**Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."**]

2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves:

- a. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

E. TSS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. [**Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."**]
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves: Motorized ball valve, steel body, and TFE seats and seals.

F. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: [30 gal. (114 L)][50 gal. (189 L)][120 gal. (454 L)]<Insert value>.

G. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230500 "Common Work Results for HVAC."
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A269/A269M, Type 304 stainless steel for steam boiler injection assemblies.

I. Injection Assembly:

1. Quill: Minimum **NPS 1/2 (DN 15)** with insertion length sufficient to discharge into at least 25

- percent of pipe diameter.
- 2. Ball Valve: **[Three][Two]**-piece stainless steel, as described in "Stainless Steel Pipes and Fittings" Article; selected to fit quill.
- 3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
- 4. Assembly Pressure/Temperature Rating: Minimum **600 psig (4137 kPa) at 200 deg F (93 deg C)**.

2.4 STAINLESS STEEL PIPES AND FITTINGS

- A. Stainless Steel Tubing: Comply with ASTM A269/A269M, Type 316.
- B. Stainless Steel Fittings: Comply with ASTM A815/A815M, Type 316, Grade WP-S.
- C. Two-Piece, Full-Port, Stainless Steel Ball Valves: ASTM A351/A351M, Type 316 stainless steel body; ASTM A276/A276M, Type 316 stainless steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and **250-psig (1725-kPa)** steam working-pressure rating and **600-psig (4140-kPa)** cold working-pressure rating.
- D. Three-Piece, Full-Port, Stainless Steel Ball Valves: ASTM A351/A351M, Type 316 stainless steel body; ASTM A276/A276M, Type 316 stainless steel stem and vented ball, threaded body design with adjustable stem packing, threaded ends, and **150-psig (1035-kPa)** steam working-pressure rating and **600-psig (4140-kPa)** cold working-pressure rating.

2.5 CHEMICAL-TREATMENT TEST EQUIPMENT

- A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounted cabinet for testing pH, TDS, TSS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.
- B. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
 - 1. **[Two]<Insert number>**-station rack for closed-loop systems.
 - 2. **[Four]<Insert number>**-station rack for open-loop systems.

2.6 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in "Performance Requirements" Article.
- B. Chemicals to be FDA approved and safe for use with direct steam injection humidification and for steam used in direct contact with food.



PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

- A. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- B. Install water-testing equipment on wall near water-chemical-application equipment.
- C. Install interconnecting control wiring for chemical-treatment controls and sensors.
- D. Mount sensors and injectors in piping circuits.
- E. Install automatic chemical-feed equipment for water, and include the following:
 - 1. Install water meter in makeup-water supply.
 - 2. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
 - a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
 - 3. Install test equipment and provide test kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 4. Install TDS controller with sensor and bleed valves.
 - a. Bleed valves to cycle, to maintain maximum TDS concentration.
 - 5. Install TSS controller with sensor and bleed valves.
 - a. Bleed valves to cycle, to maintain maximum TSS concentration.
 - 6. Install pH sensor and controller with injection pumps and solution tanks.
 - a. Injector pumps shall operate to maintain required pH.

3.3 PIPING CONNECTIONS

- A. Where installing piping adjacent to equipment, to allow service and maintenance.
- B. Make piping connections between steam system water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232113 "Hydronic Piping" for dielectric fittings.
- C. Install shutoff valves on humidifier steam system water-treatment equipment inlet and outlet. Metal



general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

- D. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.
- E. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

3.4 ELECTRICAL CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place humidifier steam system water-treatment system into operation and calibrate controls during the preliminary phase of HVAC system's startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 - 7. Cap and subject piping to static water pressure of **50 psig (345 kPa)** above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 - 8. Repair leaks and defects with new materials, and retest piping until no leaks exist.
- C. Equipment will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising Owner of changes necessary to adhere to "Performance Requirements" Article for each required characteristic. Sample boiler water at **[four][six][eight]<Insert number>**-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water



quality within performance requirements specified in this Section.

F. Comply with ASTM D3370 and with the following standards:

1. Silica: ASTM D859.
2. Steam System: ASTM D1066.
3. Acidity and Alkalinity: ASTM D1067.
4. Iron: ASTM D1068.
5. Water Hardness: ASTM D1126.

3.6 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion, scale formation, and biological growth for humidification steam and condensate piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and steam system water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.7 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain steam and condensate-treatment systems and equipment.
- B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 23 25 00 00C



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 25 00 00D - HVAC MAKEUP-WATER FILTRATION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes the following HVAC water-filtration equipment:
 - 1. HVAC makeup-water softeners.
 - 2. RO equipment for HVAC makeup water.
 - 3. Water filters, multimedia type.
 - 4. Self-cleaning strainers.
 - 5. Water filters, bag type.
 - 6. Water filters, cartridge type.
 - 7. Centrifugal separators.
 - 8. Water-softener chemicals.
- B. Related Requirements:
 - 1. Section 232513 "Water Treatment for Closed-Loop Hydronic Systems" for hydronic water-treatment equipment.
 - 2. Section 232516 "Water Treatment for Open-Loop Hydronic Systems" for hydronic heating and cooling water-treatment equipment.
 - 3. Section 232519 "Water Treatment for Steam System Feedwater" for water treatment of steam system feedwater.
 - 4. Section 232523 "Water Treatment for Humidification Steam System Feedwater" for water treatment equipment of humidification steam system feedwater.

1.2 DEFINITIONS

- A. RO: Reverse osmosis.
- B. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
 - 1. Water softeners.
 - 2. RO units.
 - 3. Water filters, multimedia type.
 - 4. Self-cleaning strainers.
 - 5. Water filters, bag type.
 - 6. Water filters, cartridge type.
 - 7. Centrifugal separators.
- B. Shop Drawings: Softeners and filtration equipment, maintenance space required, and piping connections to HVAC systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For **[water softeners][RO equipment][water-filtration units]** and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- C. Field quality-control reports.
- D. Water Analysis: Illustrate water quality available at Project site.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, **[water softeners,][RO equipment,][water-filtration units,]** and controllers to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 HVAC MAKEUP-WATER SOFTENER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[3M]**
 2. **[CSI Water Treatment Systems]**
 3. **[Culligan International Company]**
 4. **[Diamond Water Conditioning; a Griesbach company]**
 5. **[Ecodyne Limited]**
 6. **[EVOQUA Water Technologies]**
 7. **[Hungerford & Terry, Inc]**
 8. **[Hydro Service and Supplies]**
 9. **[Kinetico Incorporated]**
 10. **[Marlo Incorporated]**
 11. **[Parker Boiler]**
 12. **[Pentair, Inc.]**
 13. **[RainSoft]**
 14. **[Water King]**

15. **[WATTS; A Watts Water Technologies Company]**
 16. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[3M]**
 2. **[CSI Water Treatment Systems]**
 3. **[Culligan International Company]**
 4. **[Diamond Water Conditioning; a Griesbach company]**
 5. **[Ecodyne Limited]**
 6. **[EVOQUA Water Technologies]**
 7. **[Hungerford & Terry, Inc]**
 8. **[Hydro Service and Supplies]**
 9. **[Kinetico Incorporated]**
 10. **[Marlo Incorporated]**
 11. **[Parker Boiler]**
 12. **[Pentair, Inc.]**
 13. **[RainSoft]**
 14. **[Water King]**
 15. **[WATTS; A Watts Water Technologies Company]**
 16. **<Insert manufacturer's name>**
- C. Description: Twin mineral tanks and one brine tank, factory mounted on skid.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure, as recommended in writing by manufacturer.
- F. Mineral Tanks:
1. Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 2. Fabricate and label fiber-reinforced plastic (FRP) filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
 3. Pressure Rating: **[100 psig (690 kPa)][125 psig (860 kPa)][150 psig (1035 kPa)]<Insert value>** minimum.
 4. Wetted Components: Suitable for water temperatures from **[40 to at least 100 deg F (5 to at least 38 deg C)]<Insert range>**.
 5. Freeboard: 50 percent, minimum, for backwash expansion above the normal resin bed level.
 6. Support Legs or Skirt: Constructed of structural steel, welded or bonded to tank before testing and labeling.
 7. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication.
 8. Upper Distribution System: Single-point type, fabricated from galvanized-steel pipe and fittings.
 9. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging polyethylene strainers; arranged for even-flow distribution through resin bed.
- G. Controls: Automatic; factory mounted on mineral tanks and factory wired.
1. Adjustable duration of regeneration steps.
 2. Push-button start and complete manual operation override.
 3. Pointer on pilot-control valve to indicate cycle of operation.



4. Means of manual operation of pilot-control valve if power fails.
 5. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:
 - a. Slow opening and closing, nonslam operation.
 - b. Diaphragm guiding on full perimeter from fully open to fully closed.
 - c. Isolated dissimilar metals within valve.
 - d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
 - e. Float-operated brine valve to automatically measure the correct amount of brine to the softener and refill with fresh water.
 - f. Sampling cocks for soft water.
 6. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in **gallons (liters)** and that automatically resets after regeneration to preset total in **gallons (liters)** for next service run. Include alternator to regenerate one mineral tank with the other in service.
- H. Brine Tank: Combination measuring and wet-salt storing system.
1. Tank and Cover Material: Fiberglass a minimum of **3/16 inch (4.8 mm)** thick; or molded polyethylene a minimum of **3/8 inch (9.5 mm)** thick.
 2. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
 3. Size: Large enough for at least four regenerations at full salting.
- I. Factory-Installed Accessories:
1. Piping, valves, tubing, and drains.
 2. Sampling cocks.
 3. Main-operating-valve position indicators.
 4. Water meters.
- J. Water Test Kit: Include in wall-mounted enclosure for water softener.
- K. Capacities and Characteristics:
1. Continuous Service Flow Rate: **<Insert gpm (L/s)>** at **15-psig (104-kPa)** pressure loss.
 2. Peak Service Flow Rate: **<Insert gpm (L/s)>** at **25-psig (173-kPa)** pressure loss.
 3. Water Consumption: **<Insert gal./day (cu. m/day)>**.
 4. Water Demand: **<Insert number>** hours/day.
 5. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.
 - g. Interrupting Capacity: **<Insert amperage>**.

2.2 RO EQUIPMENT FOR HVAC MAKEUP WATER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[3M]**
 2. **[CSI Water Treatment Systems]**
 3. **[Culligan International Company]**
 4. **[Diamond Water Conditioning; a Griesbach company]**
 5. **[Ecodyne Limited]**
 6. **[EVOQUA Water Technologies]**
 7. **[Hydro Service and Supplies]**
 8. **[Marlo Incorporated]**
 9. **[Pentair, Inc.]**
 10. **[Water & Power Technologies Incorporated]**
 11. **[Water King]**
 12. **[WATTS; A Watts Water Technologies Company]**
 13. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[3M]**
 2. **[CSI Water Treatment Systems]**
 3. **[Culligan International Company]**
 4. **[Diamond Water Conditioning; a Griesbach company]**
 5. **[Ecodyne Limited]**
 6. **[EVOQUA Water Technologies]**
 7. **[Hydro Service and Supplies]**
 8. **[Marlo Incorporated]**
 9. **[Pentair, Inc.]**
 10. **[Water & Power Technologies Incorporated]**
 11. **[Water King]**
 12. **[WATTS; A Watts Water Technologies Company]**
 13. **<Insert manufacturer's name>**
- C. Description: Factory fabricated and tested with RO membrane elements in housings, high-pressure pumps and motors, controls, valves, and prefilter; mounted on skid.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.
- F. Skid Assembly: Welded-steel frame coated with epoxy protective finish.
- G. RO Membrane and Housing:
1. Element: Thin-film composite with U-cup brine seal, with minimum 98 percent salt rejection based on 2000-ppm water supplied at **225 psig (1551 kPa)** and **77 deg F (25 deg C)**.
 2. Housing: ASTM A666, Type 304 stainless steel, with PVC end caps held in place with stainless steel straps.

H. High-Pressure Pumps and Motors:

1. Pump:
 - a. Vertical, multistage, centrifugal pump, operating at 3500 rpm, with ASTM A666, Type 304 stainless steel casing, shaft, impellers, and inlet and discharge casting.
 - b. Bearings to be tungsten carbide and ceramic.
 - c. Cast-iron frame and flanged suction and discharge connections.
2. Motor: NEMA-standard, C-faced, totally enclosed, fan-cooled motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."

I. Controls:

1. Microprocessor-based controller with digital display.
2. Interlock for remote start/stop control.
3. Membrane flush sequence when pumps shut down.
4. Run time indicator.
5. Low-pressure safety cutoff.
6. Panel-mounted gages as follows:
 - a. Product and concentrate.
 - b. Inlet, cartridge filter outlet, RO feed, RO concentrate, and RO product pressures.
 - c. Product conductivity monitor.

J. Valves:

1. Stainless steel pump, concentrate, and recycle throttling valves rated for minimum **300 psig (2068 kPa)**.
2. Automatic inlet shutoff valve, diaphragm type; solenoid actuated, normally closed, and constructed of glass-reinforced noryl thermoplastic.
3. PVC valves with EPDM seats and seals for isolation at inlet, and check and sample valves at product and concentrate. Provide sample valves at cartridge filter outlet, concentrate, and product outlet.

K. Prefilter:

1. Housing: Polypropylene with built-in relief or vent valve.
2. Element: Spun-wound polypropylene.

L. Inlet Water-Tempering Valve: Thermostatic water-tempering valve to maintain [77 deg F (25 deg C)]<Insert value> inlet water temperature to RO unit.

M. Activated Carbon Filter:

1. Media Tank: Fiberglass-reinforced polyester rated for minimum **150 psig (1035 kPa)** with internal backwash distributor and filtered water collector.
2. Media: 12-by-40-mesh, bituminous coal-based activated carbon.
3. Backwash Valve: Piston-operated control valve with drain-line, flow-control orifice.
4. Backwash Control: Seven-day time clock.

N. Atmospheric Storage Tank:

1. Tank: Polyethylene single piece with closed top and flat bottom with manway in top, 0.2-micron

- filter vent, inlet, discharge, and drain piping connections, and bulkhead fittings for level controls.
 2. Control: Level switches start and stop RO unit. Low-level limit to stop repressurization pumps, and signal an alarm.
- O. Repressurization Pumps:
1. Pumps: Two close-coupled, single-stage centrifugal pumps, with mechanical seals. Wetted components to be made of ASTM A666, Type 316 stainless steel.
 2. Controls: NEMA 250, Type 4X pump control panel constructed of fiberglass to control pumps, one operating and one standby, with automatic alternator and fail-over control.
 3. Motor: Open, drip-proof motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
- P. Water Test Kit: Include in wall-mounting cabinet for RO unit.
- Q. Capacities and Characteristics:
1. RO Product Flow Rate: **<Insert gpm (L/s)>**.
 2. Total Water-Flow Rate: **<Insert gpm (L/s)>**.
 3. Daily Water Consumption: **<Insert gal./day (cu. m/day)>**.
 4. Water Demand: **<Insert number>** hours/day.
 5. Storage Tank Size: **<Insert gal. (L)>**.
 6. RO Inlet Operating Temperature: **[77 deg F (25 deg C)]<Insert value>**.
 7. High-Pressure Pump:
 - a. Discharge Pressure: **<Insert psig (kPa)>**.
 - b. Flow Rate: **<Insert gpm (L/s)>**.
 - c. Horsepower: **<Insert value>**.
 - d. Motor Speed: **[3500]<Insert number>** rpm.
 8. Repressure Pumps:
 - a. Discharge Pressure: **<Insert psig (kPa)>**.
 - b. Flow Rate: **<Insert gpm (L/s)>**.
 - c. Horsepower: **<Insert value>**.
 - d. Motor Speed: **[3500]<Insert number>** rpm.
 9. Prefilter Design (at Total Water Flow Rate):
 - a. Filter Efficiency: **[98]<Insert number>** percent.
 - b. Particle Size: **[5]<Insert number>** microns and larger.
 - c. Clean Pressure Loss: **[2 psig (14 kPa)]<Insert value>**.
 - d. Replacement Pressure Loss: **[6 psig (41 kPa)]<Insert value>**.
 10. Electrical Characteristics (Single-Point Connection):
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.
 - g. Interrupting Capacity: **<Insert amperage>**.

2.3 WATER FILTERS, MULTIMEDIA TYPE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Aqua Pure Water Conditioning]**
2. **[Diamond Water Conditioning; a Griesbach company]**
3. **[Everfilt]**
4. **[LAKOS Filtration Solutions]**
5. **[Miami Filter, Inc.]**
6. **[MWF Metro Water Filter]**
7. **[PEP Filters, Inc.]**
8. **[Puroflux Corporation]**
9. **[Sonitec-Vortisand Inc.]**
10. **[United Industries, Inc; Tower-flo Water Systems]**
11. **[Water Professionals]**
12. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Aqua Pure Water Conditioning]**
2. **[Diamond Water Conditioning; a Griesbach company]**
3. **[Everfilt]**
4. **[LAKOS Filtration Solutions]**
5. **[Miami Filter, Inc.]**
6. **[MWF Metro Water Filter]**
7. **[PEP Filters, Inc.]**
8. **[Puroflux Corporation]**
9. **[Sonitec-Vortisand Inc.]**
10. **[United Industries, Inc; Tower-flo Water Systems]**
11. **[Water Professionals]**
12. **<Insert manufacturer's name>**

- C. Description: Factory-fabricated and -tested, simplex, multimedia filter system, consisting of filter tank, media, strainer, circulating pump, piping, and controls for removing particles from water.

1. Filter Tank: Corrosion resistant with distribution system and media.
 - a. Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
 - c. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - d. Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606.
 - e. FRP Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Type A, integral;
[Designation E, 125-psig (0.862-MPa)][or][Designation F, 150-psig (1.034-MPa)] pressure category flanges of grade same as tank material in accordance with ASTM D5421.
2. Motorized Valves: Flanged or grooved-end, ductile-iron butterfly type with **[EPDM]<Insert material>** valve seat and stem seal; with ASTM B148 aluminum bronze disc.

3. Strainer: Basket type mounted on pump suction.
 4. Piping:
 - a. ASTM A53/A53M; Type S, F, or E; Grade B; Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
 - b. **ASTM B88, Type L (ASTM B88M, Type B)** copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
 5. Safety Valves: Automatic pressure relief.
 6. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
 - a. Casing: Radially split, cast iron.
 - b. Pressure Rating: **[125 psig (860 kPa)][150 psig (1035 kPa)]** minimum.
 - c. Impeller: ASTM B584 cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
 - d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
 - e. Seal: Mechanical.
 - f. Motor: Open, dripproof motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 7. Controls: Automatic control of circulating pump and tank backwash; factory wired for single electrical connection.
 - a. Panel: NEMA 250, **[Type 4]<Insert type>** enclosure with time clock and pressure gages.
 - b. Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
 - c. Backwash: Automatic; with time clock and differential pressure switch.
 - d. Backwash Valve: Tank mounted with valves interlocked to single actuator.
 8. Support: Skid mounting. **[Fabricate supports, base, and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event, when filter base is anchored to building structure.]**
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Capacities and Characteristics:
1. Filter Design:
 - a. Water Flow: **<Insert gpm (L/s)>**.
 - b. Clean Pressure Loss: **[5 psig (34.5 kPa)]<Insert value>**.
 - c. Maximum Media-Flow Rate: **[15 gpm/sq. ft. (10.2 L/s per sq. m)]<Insert value>**.
 - d. Filtration Efficiency: **[98]<Insert number>** percent.
 - e. Particle-Specific Gravity: **[1.8]<Insert number>**.
 - f. Particle Size: **[5][10][20][45]<Insert number>** microns.
 2. Filter Tank: With internal distribution piping.
 - a. Pressure Rating: **<Insert psig (kPa)>**.
 - b. Diameter: **<Insert inches (mm)>**.
 - c. Inlet and Outlet Size: **<Insert NPS (DN)>**.
 - d. Blowdown Piping Outlet Size: **<Insert NPS (DN)>**.
 3. Filter Media: **<Insert material>**.

4. Start Backwash Pressure Loss: **[13 psig (90 kPa)]<Insert value>**.
5. Backwash Period: **[10]<Insert number>** minutes.
6. Circulating Pump:
 - a. Capacity: **<Insert gpm (L/s)>**.
 - b. Total Dynamic Head: **<Insert feet (kPa)>**.
 - c. Motor Speed: **<Insert number>** rpm.
 - d. Inlet Size: **<Insert NPS (DN)>**.
 - e. Outlet Size: **<Insert NPS (DN)>**.
7. Pump Motor Size and Electrical Characteristics:
 - a. Horsepower: **<Insert value>**.
 - b. Volts: **[120][208][240][277][480]<Insert number>** V.
 - c. Phase: **[Single][Three]**.
 - d. Hertz: **[60]<Insert number>** Hz.
8. Unit Electrical Characteristics:
 - a. Full-Load Amperes: **<Insert value>**.
 - b. Minimum Circuit Ampacity: **<Insert value>**.
 - c. Maximum Overcurrent Protection: **<Insert amperage>**.
 - d. Interrupting Capacity: **<Insert amperage>**.

2.4 SELF-CLEANING STRAINERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. Everfilt.
 2. Hayward Flow Control; Hayward Industries, Inc.
 3. Islip Flow Controls Inc.
 4. Orival, Inc.
 5. Sure Flow Equipment Inc.
 6. **<Insert manufacturer's name>**.
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- C. Description: Factory-fabricated and -tested, ASTM A126, Class B, cast-iron or steel, self-cleaning strainer system of tank, strainer, backwash arm or cleaning spiral, drive and motor, piping, and controls for removing particles from water.
 1. Fabricate and label ASTM A126, Class B, cast-iron or steel strainer tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 2. Pipe Connections:
 - a. NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - b. NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- E. Motorized Valves: Flanged or grooved-end, ductile-iron angle type with [EPDM]<Insert material> valve seat and stem seal; with ASTM B148 aluminum bronze disc.
- F. Strainer: Stainless steel.
- G. Piping: ASTM A53/A53M; Type S, F, or E; Grade B; Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
- H. Safety Valves: Automatic pressure relief.
- I. Backwash Arm Drive:
 - 1. Drive Casing: Cast iron.
 - 2. Worm Gears: Immersed in oil.
 - 3. Motor: Open, dripproof motor supported on the strainer-bearing frame. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
- J. Controls: Automatic control of backwash; factory wired for single electrical connection.
 - 1. Panel: NEMA 250, [Type 4]<Insert type> enclosure with time clock and pressure gages.
 - 2. Backwash Arm Drive: Automatic and manual switching; manual switch position bypasses safeties and controls.
 - 3. Backwash: Automatic; with time clock and differential pressure switch.
 - 4. Backwash Valve: Electric actuator.
- K. Support: Skid mounting. [Fabricate supports, base, and attachment to tank with reinforcement strong enough to resist strainer movement during a seismic event, when strainer base is anchored to building structure.]
- L. Capacities and Characteristics:
 - 1. Strainer Design:
 - a. Water Flow: <Insert gpm (L/s)>.
 - b. Clean Pressure Loss: [5 psig (34.5 kPa)]<Insert value>.
 - c. Strainer Mesh: [40][60][80]<Insert number>.
 - 2. Strainer Tank: With internal distribution piping.
 - a. Material: [Cast iron][Steel]<Insert material>.
 - b. Pressure Rating: [150 psig (1034 kPa)]<Insert value>.
 - c. Inlet and Outlet Size: <Insert NPS (DN)>.
 - d. Backwash Piping Outlet Size: <Insert NPS (DN)>.
 - 3. Start Backwash: [10 psig (69 kPa)]<Insert value>.
 - 4. Backwash Period: [5]<Insert number> minutes.
 - 5. Drive Motor Size and Electrical Characteristics:
 - a. Horsepower: <Insert value>.
 - b. Volts: [120][208][240][277][480]<Insert number> V.
 - c. Phase: [Single][Three].
 - d. Hertz: [60]<Insert number> Hz.
 - 6. Unit Electrical Characteristics:

- a. Full-Load Amperes: **<Insert value>**.
- b. Minimum Circuit Ampacity: **<Insert value>**.
- c. Maximum Overcurrent Protection: **<Insert amperage>**.
- d. Interrupting Capacity: **<Insert amperage>**.

2.5 WATER FILTERS, BAG TYPE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Eden Equipment Company]**
2. **[Filtration Systems; Mechanical Mfg. Corporation]**
3. **[Hayward Flow Control; Hayward Industries, Inc.]**
4. **[Parker Hannifin Corp.; Process Filtration Div]**
5. **[Pentair, Inc.]**
6. **[PEP Filters, Inc.]**
7. **[Rosedale Products, Inc.]**
8. **[Shelco Filters]**
9. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Eden Equipment Company]**
2. **[Filtration Systems; Mechanical Mfg. Corporation]**
3. **[Hayward Flow Control; Hayward Industries, Inc.]**
4. **[Parker Hannifin Corp.; Process Filtration Div]**
5. **[Pentair, Inc.]**
6. **[PEP Filters, Inc.]**
7. **[Rosedale Products, Inc.]**
8. **[Shelco Filters]**
9. **<Insert manufacturer's name>**

- C. Description: **[Floor-mounted housing][Housing]** with filter bags for removing particles from water.

1. Housing: Corrosion resistant; designed to separate inlet from outlet and to direct inlet through bag-type water filter; with **[bag support and]**base, feet, or skirt.
 - a. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 - b. Steel Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606.
 - c. Plastic Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: **150-psig (1035-kPa)** plastic flanges.
2. Bag: Replaceable; of shape to fit housing.

- D. Capacities and Characteristics:

1. Filter Design:
 - a. Water-Flow Rate: **<Insert gpm (L/s)>**.
 - b. Filtration Efficiency: **[98]<Insert number>** percent.

- c. Particle Size: [10][20]<Insert number> microns and larger.
 - d. Clean Pressure Loss: [2 psig (14 kPa)]<Insert value>.
 - e. Pressure Loss at Replacement: [6 psig (41 kPa)]<Insert value>.
- 2. Housing:
 - a. Material: [Carbon steel][Plastic].
 - b. Pressure Rating: <Insert psig (kPa)>.
 - c. Seal Material: [Nitrile rubber]<Insert material>.
 - d. Diameter: <Insert inches (mm)>.
 - e. Height or Length: <Insert inches (mm)>.
 - f. Inlet and Outlet Size: <Insert NPS (DN)>.
 - g. Drain Size: [Not applicable]<Insert NPS (DN)>.
 - h. Bag Support Basket Material: [Stainless steel]<Insert material>.
- 3. Bag:
 - a. Number Required: <Insert number>.
 - b. Nominal Diameter: <Insert inches (mm)>.
 - c. Nominal Length: <Insert inches (mm)>.
 - d. Media Material: [Cotton][Polyester][Polypropylene]<Insert material>.

2.6 WATER FILTERS, CARTRIDGE TYPE

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. [Eden Equipment Company]
 - 2. [Filtration Systems; Mechanical Mfg. Corporation]
 - 3. [Hayward Flow Control; Hayward Industries, Inc.]
 - 4. [Parker Hannifin Corp.; Process Filtration Div]
 - 5. [Pentair, Inc.]
 - 6. [PEP Filters, Inc.]
 - 7. [Rosedale Products, Inc.]
 - 8. [Shelco Filters]
 - 9. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. [Eden Equipment Company]
 - 2. [Filtration Systems; Mechanical Mfg. Corporation]
 - 3. [Hayward Flow Control; Hayward Industries, Inc.]
 - 4. [Parker Hannifin Corp.; Process Filtration Div]
 - 5. [Pentair, Inc.]
 - 6. [PEP Filters, Inc.]
 - 7. [Rosedale Products, Inc.]
 - 8. [Shelco Filters]
 - 9. <Insert manufacturer's name>
- C. Description: [Floor-mounted housing][Housing] with filter cartridges for removing particles from water.
 - 1. Housing: Corrosion resistant; designed to separate inlet from outlet and to direct inlet through cartridge-type water filter; with base, feet, or skirt.

- a. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
- b. Steel Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606.
- c. Plastic Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: **150-psig (1035-kPa)** plastic flanges.

2. Cartridge: Replaceable; of shape to fit housing.

D. Capacities and Characteristics:

1. Filter Design:

- a. Water-Flow Rate: **<Insert gpm (L/s)>**.
- b. Filtration Efficiency: **[98]<Insert number>** percent.
- c. Particle Size: **[10][20]<Insert number>** microns and larger.
- d. Clean Pressure Loss: **[2 psig (14 kPa)]<Insert value>**.
- e. Pressure Loss at Replacement: **[6 psig (41 kPa)]<Insert value>**.

2. Housing:

- a. Material: **[Carbon steel][Plastic]**.
- b. Pressure Rating: **<Insert psig (kPa)>**.
- c. Seal Material: **[Nitrile rubber]<Insert material>**.
- d. Diameter: **<Insert inches (mm)>**.
- e. Height or Length: **<Insert inches (mm)>**.
- f. Inlet and Outlet Size: **<Insert NPS (DN)>**.
- g. Drain Size: **[Not applicable]<Insert NPS (DN)>**.

3. Cartridge:

- a. Number Required: **<Insert number>**.
- b. Nominal Diameter: **<Insert inches (mm)>**.
- c. Nominal Length: **<Insert inches (mm)>**.
- d. Media Material: **[Cotton][Polyester][Polypropylene]<Insert material>**.

2.7 CENTRIFUGAL SEPARATORS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Culligan International Company]**
2. **[Griswold Water Systems]**
3. **[LAKOS Filtration Solutions]**
4. **[PEP Filters, Inc.]**
5. **[Puroflux Corporation]**
6. **[Rosedale Products, Inc.]**
7. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Culligan International Company]**

2. [Griswold Water Systems]
 3. [LAKOS Filtration Solutions]
 4. [PEP Filters, Inc.]
 5. [Puroflux Corporation]
 6. [Rosedale Products, Inc.]
 7. <Insert manufacturer's name>
- C. Description: Simplex separator housing, with baffles and chambers for removing particles from water by centrifugal action and gravity.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Housing: With manufacturer's proprietary system of baffles and chambers.
1. Construction: Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 2. Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
 3. Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.
 4. Collection Chamber: Designed to hold separated particles.
 5. Outlet: Near top of unit.
 6. Purge: At bottom of collection chamber.
 7. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded in accordance with ASME B1.20.1.
 8. Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606. Provide stainless steel flanges if tank is stainless steel.
- F. Motorized Purge Valve: Gate or plug pattern valve.
1. Motorized Valves: Butterfly-type, flanged or grooved-end, ductile-iron body, with [EPDM]<Insert material> valve seat and stem seal; with ASTM B148 aluminum bronze disc.
- G. Strainer: Stainless steel basket type mounted on pump suction.
- H. Piping:
1. ASTM A53/A53M; Type S, F, or E; Grade B; Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding or ductile-iron fittings.
 2. **ASTM B88, Type L (ASTM B88M, Type B)** copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
- I. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
1. Casing: Radially split, cast iron.
 2. Pressure Rating: [125 psig (860 kPa)][150 psig (1035 kPa)] minimum.
 3. Impeller: ASTM B584 cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
 4. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
 5. Seal: Mechanical.
 6. Motor: Open, dripproof motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
- J. Controls: Automatic control of circulating pump and separator purge; factory wired for single electrical connection.

1. Panel: NEMA 250, [Type 4]<Insert type> enclosure.
 2. Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
 3. Separator Purge: Automatic and manual.
 4. TSS Controller Interlock: Open separator purge valve with bleed-off control.
- K. Support: Skid mounting. [Fabricate supports, base, and attachment to separator housing with reinforcement strong enough to resist separator movement during a seismic event, when separator base is anchored to building structure.]
- L. Capacities and Characteristics:
1. Separator Design:
 - a. Water-Flow Rate: <Insert gpm (L/s)>.
 - b. Pressure Loss: [5 psig (34.5 kPa)]<Insert value>.
 - c. Separator Efficiency: [98]<Insert number> percent.
 - d. Particle-Specific Gravity: [1.8]<Insert number>.
 - e. Particle Size: [5][10][20][45]<Insert number> microns.
 2. Housing:
 - a. Material: [Steel][Stainless steel][Plastic][Fiberglass]<Insert material>.
 - b. Pressure Rating: <Insert psig (kPa)>.
 - c. Diameter: <Insert inches (mm)>.
 - d. Height: <Insert inches (mm)>.
 - e. Inlet and Outlet Size: <Insert NPS (DN)>.
 - f. Purge Size: <Insert NPS (DN)>.
 3. Circulating Pump:
 - a. Capacity: <Insert gpm (L/s)>.
 - b. Total Dynamic Head: <Insert feet (kPa)>.
 - c. Motor Speed: <Insert number> rpm.
 - d. Inlet Size: <Insert NPS (DN)>.
 - e. Outlet Size: <Insert NPS (DN)>.
 4. Pump Motor Size and Electrical Characteristics:
 - a. Horsepower: <Insert value>.
 - b. Volts: [120][208][240][277][480]<Insert number> V.
 - c. Phase: [Single][Three].
 - d. Hertz: [60]<Insert number> Hz.
 - e. Full-Load Amperes: <Insert value>.
 - f. Minimum Circuit Ampacity: <Insert value>.
 - g. Maximum Overcurrent Protection: <Insert amperage>.
 - h. Interrupting Capacity: <Insert amperage>.

2.8 WATER-SOFTENER CHEMICALS

- A. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity to be a minimum **30,000 grains/cu. ft. (69 kg/cu. m)** of calcium carbonate of resin when regenerated with **15 lb (6.8 kg)** of salt.



- B. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are unacceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION OF EQUIPMENT

- A. Equipment Mounting:
 - 1. Install **[water-softener][water-filtration]** equipment on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 INSTALLATION OF WATER SOFTENER

- A. Install water-softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
- B. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.
- C. Prepare mineral-tank distribution system and underbed for minerals, and place specified mineral into mineral tanks.
- D. Install water-testing sets on wall adjacent to water softeners.

3.4 INSTALLATION OF RO UNIT

- A. Install RO unit and storage tank on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor RO unit and storage tank with pumps to substrate.
- B. Install interconnecting piping and controls furnished by equipment manufacturer but not factory installed.
- C. Install water-testing sets on wall adjacent to RO unit.

3.5 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Where installing piping adjacent to equipment, allow space for service and maintenance.
- C. Make piping connections between HVAC **[water-softener][water-filtration]** equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232113 "Hydronic Piping."
- D. Install shutoff valves on HVAC **[water-softener][water-filtration]** equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."
- E. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.
- F. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

3.6 ELECTRICAL CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC **[water-softener][water-filtration]** system into operation, and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 - 7. Cap and subject piping to static water pressure of **50 psig (345 kPa)** above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 - 8. Repair leaks and defects with new materials and retest piping until no leaks exist.
- C. Equipment will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.



3.8 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion, scale formation, and biological growth for equipment. Services and chemicals to be provided for a period of one year from date of Substantial Completion, and to include the following:
1. Periodic field service and consultation.
 2. Customer report charts and log sheets.
 3. Laboratory technical analysis.
 4. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.
- B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 23 25 00 00D



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 25 13 00 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water treatment for closed-loop hydronic systems.
2. Manual chemical-feed equipment.
3. Automatic chemical-feed equipment.
4. Chemicals.
5. Inhibited ethylene glycol and propylene glycol.

B. Related Requirements:

1. Section 232533 "HVAC Makeup-Water Filtration Equipment" for water treatment of water softeners, RO equipment, and filtration equipment.

1.2 DEFINITIONS

- A. RO:** Reverse osmosis.
- B. TDS:** Total dissolved solids consist of salts and other materials that combine with water as a solution.
- C. TSS:** Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Bypass feeders.
2. Water meters.
3. Inhibitor injection timers.
4. pH controllers.
5. Chemical solution tanks.
6. Injection pumps.
7. Chemical-treatment test equipment.
8. Chemical material safety data sheets.
9. Inhibited ethylene glycol.
10. Inhibited propylene glycol.

B. Shop Drawings: Pretreatment and chemical-treatment equipment, showing tanks, maintenance space required, and piping connections to hydronic systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.



1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- C. Field quality-control reports.
- D. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
- E. Water Analysis: Illustrate water quality available at Project site.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Anderson Chemical Company]**
 - 2. **[Aqua-Chem, Inc.]**
 - 3. **[Barclay Water Management, Inc]**
 - 4. **[Boland Trane Services]**
 - 5. **[Cascade Water Services, Inc]**
 - 6. **[Earthwise Environmental Inc]**
 - 7. **[H-O-H Water Technology, Inc]**
 - 8. **[Metro Group, Inc. (The)]**
 - 9. **[Nalco; an Ecolab company]**
 - 10. **[Sonitec-Vortisand Inc.]**

11. [Suez Water Technologies (Formerly GE Water)]
12. [Watcon, Inc]
13. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Anderson Chemical Company]
2. [Aqua-Chem, Inc.]
3. [Barclay Water Management, Inc]
4. [Boland Trane Services]
5. [Cascade Water Services, Inc]
6. [Earthwise Environmental Inc]
7. [H-O-H Water Technology, Inc]
8. [Metro Group, Inc. (The)]
9. [Nalco; an Ecolab company]
10. [Sonitec-Vortisand Inc.]
11. [Suez Water Technologies (Formerly GE Water)]
12. [Watcon, Inc]
13. <Insert manufacturer's name>

2.2 PERFORMANCE REQUIREMENTS

- A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems, as indicated in this Specification. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C. Closed hydronic systems, including [hot-water heating below 250 deg F (120 deg C)][chilled water][dual-temperature water][glycol heating][and][glycol cooling] shall have the following water qualities:
1. pH: Maintain a value within <Insert range>.
 2. Alkalinity: Maintain a value within <Insert range> mg/L as CaCO₃.
 3. Steel Corrosion Inhibitors: Provide sufficient inhibitors to limit mild steel corrosion to <Insert number> mils per year. Maintain soluble iron concentrations at or below <Insert value> mg/L.
 4. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to <Insert number> mils per year. Maintain soluble copper concentrations at or below <Insert value> mg/L.
 5. Scale Control: Provide softened water for initial fill and makeup. [Where softened water is not used, provide sufficient scale inhibitors to prevent formation of scale and maintain all scale-forming material in solution.]
 6. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
 7. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of <Insert number> organisms/mL.
 - b. Total Anaerobic Plate Count: Maintain a maximum value of <Insert number> organisms/mL.
 - c. Nitrate Reducers: Maintain a maximum value of <Insert number> organisms/mL.
 - d. Sulfate Reducers: Maintain a maximum value of <Insert number> organisms/mL.
 - e. Iron Bacteria: Maintain a maximum value of <Insert number> organisms/mL.

8. <Insert other applicable requirements>.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

- A. Bypass Feeders: Provide steel feeders with corrosion-resistant exterior coating, minimum **3-1/2-inch (89-mm)** fill opening in the top, and **NPS 3/4 (DN 20)** bottom inlet and top side outlet. Provide quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
1. Capacity: **[2 gal. (7.6 L)][5 gal. (19 L)]<Insert value>**.
 2. Minimum Working Pressure: **[125 psig (860 kPa)][175 psig (1210 kPa)]<Insert value>**.

2.4 AUTOMATIC CHEMICAL-FEED EQUIPMENT

- A. Water Meter, Piston Type, Threaded:
1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
 2. Body: Bronze.
 3. Minimum Working-Pressure Rating: **150 psig (1035 kPa)**.
 4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
 5. Registration: **Gallons (Liters) or cubic feet (cubic meters)**.
 6. End Connections: Threaded.
 7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
 8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
 9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**
- B. Water Meter, Turbine Type, Threaded:
1. AWWA C701, turbine-type, totalization meter.
 2. Body: Bronze.
 3. Minimum Working-Pressure Rating: **100 psig (690 kPa)**.
 4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
 5. Registration: **Gallons (Liters) or cubic feet (cubic meters)**.
 6. End Connections: Threaded.
 7. **[Controls: Flow-control switch with normally open contacts. rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
 8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
 9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**
- C. Water Meter, Turbine Type, Flanged:
1. AWWA C701, turbine-type, totalization meter.
 2. Body: **[Bronze][Epoxy-coated cast iron]**.
 3. Minimum Working-Pressure Rating: **150 psig (1035 kPa)**.
 4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
 5. Registration: **Gallons (Liters) or cubic feet (cubic meters)**.

6. End Connections: Flanged.
7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**

D. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: **[30 gal. (114 L)][50 gal. (189 L)][120 gal. (454 L)]<Insert value>**.

E. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230500 "Common Work Results for HVAC."
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A269/A269M, Type 304 stainless steel for steam boiler injection assemblies.

G. Injection Assembly:

1. Quill: Minimum **NPS 1/2 (DN 15)** with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: **[Three][Two]**-piece, stainless steel; selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum **600 psig (4137 kPa) at 200 deg F (93 deg C)**.

2.5 CHEMICAL-TREATMENT TEST EQUIPMENT

- A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounted cabinet for testing pH, corrosion inhibitors, alkalinity, hardness, and other properties recommended by manufacturer.
- B. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
 1. **[Two]<Insert number>**-station rack for closed-loop systems.

2.6 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer, compatible with piping system components and connected equipment, and able to attain water quality specified in "Performance Requirements" Article.

2.7 INHIBITED ETHYLENE GLYCOL AND PROPYLENE GLYCOL

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Dynalene]**
2. **[Fremont Industries]**
3. **[Houghton Chemical Corp.]**
4. **[The Dow Chemical Company]**
5. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Dynalene]**
2. **[Fremont Industries]**
3. **[Houghton Chemical Corp.]**
4. **[The Dow Chemical Company]**
5. **<Insert manufacturer's name>**

- C. Inhibited Ethylene Glycol:

1. Ethylene glycol with inhibitor additive, to provide freeze protection for heat-transfer fluid and corrosion protection for carbon-steel, brass, copper, stainless steel, and cast-iron piping and fittings.
2. Inhibitor creates a passive layer on all surfaces that contact ethylene glycol to prevent corrosion and stabilizes fluid pH, to compensate for acids formed from glycol degradation.
3. pH value shall be maintained between **[9.0 and 10.5]<Insert range>**, with reserve alkalinity greater than **[12]<Insert number> mL**.
4. Concentrated inhibited ethylene glycol is to be 95.5 percent ethylene glycol by weight and 4.5 percent performance additives.
5. Concentrated inhibited ethylene glycol is mixed with water in proper proportion specified by the manufacturer to provide freeze protection to **[minus 20 deg F (minus 29 deg C)]<Insert number>**. Premixed heat-transfer fluid may be used, or glycol/water mixture may be prepared at time of installation. Use only deionized water for mixing.
6. Provide only ethylene glycol that is specifically blended for HVAC application. Automotive-type antifreeze is unacceptable.

- D. Inhibited Propylene Glycol:

1. Propylene glycol with inhibitor additive, to provide freeze protection for heat-transfer fluid and corrosion protection for carbon steel, brass, copper, stainless steel, and cast-iron piping and fittings.
2. Inhibitor creates a passive layer on all surfaces that contact propylene glycol to prevent corrosion and stabilizes fluid pH, to compensate for acids formed from glycol degradation.
3. pH value shall be maintained between **<Insert range>**, with reserve alkalinity greater than **<Insert number> mL**.

4. Concentrated inhibited propylene glycol is to be 95.5 percent propylene glycol by weight and 4.5 percent performance additives.
5. Concentrated inhibited propylene glycol is mixed with water in proper proportion specified by the manufacturer to provide freeze protection to **[minus 20 deg F (minus 29 deg C)]<Insert number>**. Premixed heat-transfer fluid may be used, or glycol/water mixture may be prepared at the time of installation. Use only deionized water for mixing.
6. Provide only propylene glycol that is specifically blended for HVAC application. Automotive-type antifreeze is unacceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

- A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate. Install all chemical application equipment within a spill-containment area without floor drain.
- B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install water-testing equipment on wall near water-chemical-application equipment.
- D. Install interconnecting control wiring for chemical-treatment controls and sensors.
- E. Mount sensors and injectors in piping circuits.
- F. Bypass Feeders: Install in closed hydronic systems, including **[hot-water heating,][chilled water,][dual-temperature water,][glycol heating,][and][glycol cooling]**, and equip with the following:
 1. Install bypass feeder in a bypass circuit around circulating pumps unless indicated otherwise on Drawings.
 2. Install water meter in makeup-water supply.
 3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
 5. Install a swing check on the inlet after the isolation valve.
- G. Install automatic fluid make-up equipment for glycol water system, and include the following:
 1. Chemical solution tanks.
 2. Chemical solution injection pumps.
 3. Water meter in makeup supply to system.
 4. Pressure switch to operate injection pump as necessary to maintain glycol system pressure.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.
- C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."
- D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."
- E. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

3.4 ELECTRICAL CONNECTIONS

- A. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 7. Cap and subject piping to static water pressure of **50 psig (345 kPa)** above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 8. Repair leaks and defects with new materials, and retest piping until no leaks exist.
- E. Equipment will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. At **[four][six][eight]<Insert number>**-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis, advising Owner of changes necessary to adhere to "Performance Requirements" Article.
- H. Comply with ASTM D3370 and with the following standards:
1. Silica: ASTM D859.
 2. Acidity and Alkalinity: ASTM D1067.
 3. Iron: ASTM D1068.
 4. Water Hardness: ASTM D1126.

3.6 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion and scale formation for hydronic piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:
1. Initial water analysis and HVAC water-treatment recommendations.
 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 3. Periodic field service and consultation.
 4. Customer report charts and log sheets.
 5. Laboratory technical analysis.
 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.7 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 23 25 13 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 25 13 00	22 12 23 26	Facility Fuel-Oil Piping
23 25 13 00	23 21 13 00	Hydronic Piping
23 25 13 00	23 25 00 00	HVAC Water Treatment
23 25 13 00	23 25 00 00a	Water Treatment for Open-Loop Hydronic Systems
23 25 13 00	23 25 00 00b	Water Treatment for Steam System Feedwater
23 25 13 00	23 25 00 00c	Water Treatment for Humidification Steam System Feedwater
23 25 13 00	23 25 00 00d	HVAC Makeup-Water Filtration Equipment



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 31 00 00 - SHOP-FABRICATED HVAC CASINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Shop-fabricated casings.
2. Casing interstitial insulation.
3. Casing liner.
4. Sealant materials.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For adhesives, indicating VOC content.
3. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
4. Product Data: For sealants, indicating VOC content.
5. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
6. Laboratory Test Reports: For antimicrobial coatings, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For HVAC casings.

1. Include plans, elevations, sections, and attachment details.
2. Include details of HVAC casing assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Sheet metal thickness(es).
 - b. Insulation.
 - c. Reinforcement and spacing.
 - d. Seam and joint construction.
 - e. Access doors including frames, hinges, and latches.
 - f. Fan, filter, coil, humidifier, and other apparatus being installed in and mounted on casing.
 - g. Locations for access to internal components.
 - h. Hangers and supports including methods for building attachment, vibration isolation, **[seismic restraints,]**and casing attachment.
 - i. Interior lighting, including switches.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for shop-fabricated HVAC casings, accessories, and components, from fabricator.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Welding certificates.
- C. Product Certificates: For each type of casing.
 - 1. For insulation properties, for the insulation material, and complete panel assembly, from fabricator.
 - 2. For static-pressure ratings of complete panel assembly, from fabricator.
 - 3. Product Certificates: For acoustical performance of each casing, from fabricator.
 - a. Show sound-absorption coefficients in each octave band. Coefficients to be equal to or lower than those scheduled when tested in accordance with ASTM C423.
 - b. Show airborne sound transmission losses. Losses to be equal to or lower than those scheduled when tested in accordance with ASTM E90.
 - 4. Casing Performance: Submit calculations indicating that the proposed casing construction will achieve the required static-pressure classification, acoustical performance, and structural performance.
- D. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with **[AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports][and][AWS D9.1/D9.1M, "Sheet Metal Welding Code," for casing joint and seam welding]**.

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases **[and roof curbs]**with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Verify that base height is sufficient to accommodate required drain trap depth.
- B. Coordinate sizes and locations of steel supports. Supports are specified in Section 055000 "Metal Fabrications."
- C. Coordinate installation of roof curbs, **[equipment supports,]**and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

1. Verify that roof curb height is sufficient to accommodate required drain trap depth.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Static-Pressure Classes:

1. Upstream from Fan(s): **[2 (500)]<Insert number> inch wg (Pa).**
2. Downstream from Fan(s): **[2 (500)][3 (750)][4 (1000)][6 (1500)][10 (2500)]<Insert number> inch wg (Pa).**

B. Thermal Performance for Assembled Casing Panel:

1. 2-Inch (50-mm) Panel: **[0.12 (0.68)]<Insert number> Btu/h x sq. ft. x deg F (W/sq. m x K).**
2. 4-Inch (100-mm) Panel: **[0.06 (0.34)]<Insert number> Btu/h x sq. ft. x deg F (W/sq. m x K).**

C. Acoustical Performance for Assembled Casing Panel:

1. NRC: **[1.09][0.94]<Insert number>** in accordance with ASTM C423.
2. STC: **[40][34]<Insert number>** in accordance with ASTM E90.

D. Structural Performance:

1. Fabricate casings to withstand **[133]<Insert number>** percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed **[1/8 (0.97)]<Insert deflection> inch/foot (mm/m).**
 - a. Fabricate outdoor casings to withstand wind load of **[15 (720)]<Insert number> lbf/sq. ft (N/sq. m).**
 - b. Fabricate outdoor casings to withstand snow load of **[30 (1440)]<Insert number> lbf/sq. ft. (N/sq. m).**

E. Flammability:

1. Insulation and Other Materials Exposed to the Airstream:
 - a. All materials exposed to the airstream to comply with requirements of NFPA 90A or NFPA 90B when tested in accordance with ASTM E84.

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

G. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

H. Seismic Performance: HVAC casings shall withstand the effects of earthquake motions determined in accordance with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" **[and][ASCE/SEI 7]<Insert requirement>.**

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"



2. Component Importance Factor: **[1.5][1.0]**.
3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 GENERAL CASING FABRICATION REQUIREMENTS

- A. General Casing Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 9, "Equipments and Casings," for acceptable construction details related to required static-pressure classes.
- B. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 9, "Equipment and Casings," for acceptable materials, material thicknesses, and casing construction methods unless otherwise indicated. Sheet metal materials to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
 1. Fabricate casings with more than **3-inch wg (750-Pa)** negative static pressure in accordance with SMACNA's "Rectangular Industrial Duct Construction Standards."
 2. Fabricate casings with more than **2-inch wg (500-Pa)** positive static pressure in accordance with SMACNA's "Rectangular Industrial Duct Construction Standards."
- C. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 1. Exterior-Surface Galvanized Coating Designation: **[G60 (Z180)][G90 (Z275)]**.
 2. Interior-Surface Galvanized Coating Designation:
 - a. Sections Not Exposed to Moisture: **[G60 (Z180)][G90 (Z275)]**.
 - b. Sections Housing and Downstream from Cooling Coil and Humidifiers: **[G90 (Z275)]**.
- D. Stainless Steel: ASTM A480/A480M, **[Type 304][Type 316]**, and having a **[No. 2D]<Insert finish>** finish.
- E. Shop-Applied Antimicrobial Coating:
 1. Apply to the interior sheet metal surfaces of casing in contact with the airstream. Apply untreated clear coating to the exterior surface.
 2. Use only antimicrobial compound tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 3. Coating Hardness: 2H minimum when tested in accordance with ASTM D3363.
 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 in accordance with UL 723; certified by an NRTL.
 5. Applied Coating Color: **[Standard][Black][White]**.
- F. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
- G. Sealing Requirement: SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class A. Seal all seams, joints, connections, and abutments to building.
- H. Access Doors: Fabricate access doors in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 9-15, "Casing Access Doors - 2-inch wg (500 Pa)," and Figure 9-16, "Casing Access Doors - 3-10-inch wg (750-2500 Pa)"; and in accordance with pressure class of the plenum or casing section in which access doors are to be installed.
 1. Size: **[20 by 54 (500 by 1370)]<Insert dimensions> inches (mm)**.

2. Vision Panel: Double-glazed, wire-reinforced safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
 3. Hinges: Piano or butt hinges and latches; number and size in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 4. Latches: Minimum of two wedge-lever-type latches; operable from inside and outside.
 5. Neoprene gaskets around entire perimeters of door frames.
 6. Install doors to open against air pressure.
- I. Condensate Drain Pans: Formed sections of **[Type 304, stainless steel sheet][G90 (Z275) coated, galvanized sheet steel]** complying with requirements in ASHRAE 62.1. Extend pans a minimum of **12 inches (300 mm)** past coil.
1. Construct pans with a double-wall having space between walls filled with foam insulation and sealed moisture tight.
 2. Insulation: Polystyrene or polyurethane.
 3. For units with stacked coils or stacked eliminators, provide intermediate drain pan or drain trough to collect condensate from each coil row. Provide downcomer to conduct condensate from intermediate pan or trough into lower drain pan. Intermediate drain pan, trough, and downcomer to be constructed of **[20-gauge (1.05-mm), Type 304, stainless][18-gauge (1.31-mm) galvanized]** steel.
 4. Slope drain pan floor in a minimum of two planes to collect condensate from cooling coils (including coil piping connections and return bends), eliminators, and humidifiers when units are operating at maximum catalogued face velocity across cooling coil. All condensate to drain from pan without any standing water.
 5. Provide trap for each drain pan connection. Dimension trap as detailed on Drawings.

2.3 SHOP-FABRICATED CASINGS

- A. Single- and Double-Wall Casings: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.
1. Outer Panel: **[Galvanized sheet steel][Type 304, stainless steel sheet]**.
- B. Fabricate casings with standing seams and angle-iron reinforcements unless otherwise indicated.
- C. Fabricate close-off sheets from casing to dampers, filter frames, and coils and between stacked coils. Use **[G90 (Z275) galvanized sheet steel][Type 304, stainless steel sheets]** of same thickness as outer casing.
- D. Bolt close-off sheets to frame flanges and housings. Support coils on stands fabricated from galvanized-steel angles or channels.
- E. Reinforce casings with galvanized-steel angles.
- F. Double-Wall Casing Inner Panel, Perforated: Galvanized sheet steel having **3/32-inch- (2.4-mm-)** diameter perforations, with overall open area of **[23]<Insert number>** percent. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.
- G. Double-Wall Casing Inner Panel, Solid: Sheet steel. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

2.4 CASING INTERSTITIAL INSULATION

- A. Casing insulation is used to fill the interstitial void between inner and outer panel wall in double-wall casing construction and provides thermal and acoustic insulation.
- B. Interstitial Insulation, Polyurethane Foam: Polyurethane foam complying with requirements of NFPA 90A or NFPA 90B when tested in accordance with ASTM E84.
 - 1. Casing Wall Thickness: [2 (50)][4 (100)]<Insert dimension> inches (mm).
 - 2. Maximum Thermal Conductivity: [0.27 (0.039)]<Insert conductivity> Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature.
- C. Interstitial Insulation, Fibrous Glass: Fibrous-glass insulation complying with ASTM E84, NFPA 90A, or NFPA 90B; and with NAIMA AH124.
 - 1. Casing Wall Thickness: [2 (50)][4 (100)]<Insert dimension> inches (mm).
 - 2. Maximum Thermal Conductivity of Composite Panel: [0.27 (0.039)]<Insert conductivity> Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature.
 - 3. Coat insulation with antimicrobial coating.
 - 4. Cover insulation with polyester film complying with NFPA 701.
- D. Interstitial Insulation, Polyurethane-Foam and Fibrous-Glass Combination: Polyurethane foam in combination with fibrous glass for enhanced sound absorption characteristics.
 - 1. Polyurethane-Foam Insulation Thickness: [1 (25)][2 (50)]<Insert dimension> inch(es (mm)).
 - 2. Fibrous-Glass Insulation Thickness: [1 (25)][2 (50)]<Insert dimension> inch(es (mm)).
 - 3. Maximum Thermal Conductivity of Composite Panel: [0.27 (0.039)]<Insert conductivity> Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature.
 - 4. Coat insulation with antimicrobial coating.
 - 5. Cover insulation with polyester film complying with NFPA 701.
- E. Interstitial Insulation: Flexible-elastomeric duct insulation complying with ASTM C534/C534M, Type II for sheet materials and with ASTM E84 and NFPA 90A or NFPA 90B.
 - 1. Casing wall thickness to be [1 inch (25 mm)][2 inches (50 mm)].
 - 2. Maximum Thermal Conductivity: [0.25 (0.036)]<Insert conductivity> Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature.

2.5 CASING LINER

- A. Casing liner is applied to the inner side of the panel in single-wall casing construction and provides thermal and acoustic insulation. The inner surface is exposed to the airstream.
- B. Fibrous-Glass Casing Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124.
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CertainTeed; SAINT-GOBAIN]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [Knauf Insulation]

- d. **[Owens Corning]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Owens Corning]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain casing liner from single source from single manufacturer.
 4. Maximum Thermal Conductivity:
 - a. Type I, Flexible: **[0.27 (0.039)]<Insert conductivity> Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C)** mean temperature.
 - b. Type II, Rigid: **[0.23 (0.033)]<Insert conductivity> Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C)** mean temperature.
 5. Antimicrobial Erosion-Resistant Coating: Apply to surface of the liner that will form the interior surface of casing to act as a moisture repellent and an erosion-resistant coating. Use only antimicrobial compound tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 6. **[Solvent][Water]-Based Liner Adhesive:** Comply with NFPA 90A or NFPA 90B and with ASTM C916.
 - a. Adhesive shall have a VOC content of 80 g/L or less.
 - b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - c. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - d. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - e. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - f. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- C. Flexible-Elastomeric Casing Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1, and with NFPA 90A or NFPA 90B.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. [Aeroflex USA]
 - b. [Armacell LLC]
 - c. [K-Flex USA]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Aeroflex USA]
 - b. [Armacell LLC]
 - c. [K-Flex USA]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain casing liner from single source from single manufacturer.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
5. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - a. Adhesive shall have a VOC content of 80 g/L or less.
 - b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - c. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - d. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - e. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - f. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- D. Natural-Fiber Casing Liner: Cotton fiber with polybinding fibers, treated with fire retardant and microbial growth inhibitor. Complying with ASTM E84 and NFPA 90A or NFPA 90B.
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Acoustical Surfaces, Inc.]
 - b. [Bonded Logic, Inc.]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Acoustical Surfaces, Inc.]**
 - b. **[Bonded Logic, Inc.]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain casing liner from single source from single manufacturer.
 4. Maximum Thermal Conductivity: **[0.24 (0.034)]<Insert conductivity> Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C)** mean temperature when tested in accordance with ASTM C518.
 5. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
 6. Liner Adhesive: As recommended by insulation manufacturer and complying with ASTM E84 and NFPA 90A or NFPA 90B.
 - a. Adhesive shall have a VOC content of 80 g/L or less.
 - b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - c. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - d. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - e. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - f. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- E. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, **[0.106-inch- (2.6-mm-)] [0.135-inch- (3.5-mm-)]** diameter shank, length to suit depth of insulation indicated with integral **1-1/2-inch (38-mm)** galvanized carbon-steel washer.
 2. Insulation-Retaining Washers: Self-locking washers formed from **0.016-inch- (0.41-mm-)** thick, **[galvanized][stainless]** steel, with beveled edge sized as required to hold insulation securely in place, but not less than **1-1/2 inches (38 mm)** in diameter.
- F. Shop or Factory Application of Casing Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of casing liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of casing liner is prohibited.
 2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 3. Butt transverse joints without gaps, and coat joint with adhesive.
 4. Fold and compress liner in corners of casings or cut and fit to ensure butted-edge overlapping.
 5. Apply adhesive coating on longitudinal seams in casings with air velocity of **2500 fpm (12.7 m/s)**.
 6. Secure liner with mechanical fasteners **4 inches (100 mm)** from corners and at intervals not exceeding **12 inches (300 mm)** transversely; at **3 inches (75 mm)** from transverse joints and at intervals not exceeding **18 inches (450 mm)** longitudinally.

7. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from casing wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined casing preceding unlined duct.
 - c. Upstream edges of transverse joints in casings where air velocities are higher than **2500 fpm (12.7 m/s)** or where indicated.
8. Secure insulation between perforated sheet metal inner wall of same thickness as specified for outer wall. Use mechanical fasteners that maintain inner wall at uniform distance from outer wall without compressing insulation.

2.6 SEALANT MATERIALS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets to have a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:
 1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. Sealant shall have a VOC content of 420 g/L or less.
 7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 8. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 10. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 11. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
 12. Maximum Static-Pressure Class: **10 inch wg (2500 Pa)**, positive or negative.
 13. Service: Indoor or outdoor.
 14. Substrate: Compatible with galvanized sheet steel or stainless steel.
- C. Solvent-Based Joint and Seam Sealant:
 1. Application Method: Brush on.
 2. Base: Synthetic rubber resin.
 3. Solvent: Toluene and heptane.

4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Sealant shall have a VOC content of 420 g/L or less.
9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
10. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
11. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
12. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
13. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
14. Maximum Static-Pressure Class: **10 inch wg (2500 Pa)**, positive or negative.
15. Service: Indoor or outdoor.
16. Substrate: Compatible with galvanized sheet steel or stainless steel.

D. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single component, acid curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
8. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
10. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
11. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine [**concrete bases**][**roof curbs**][and][**steel supports**] for compliance with requirements for conditions affecting installation and performance of HVAC casings. Verify that there is sufficient clearance for access and to install all piping, condensate traps, ductwork, and other fittings.
- B. Examine casing insulation materials and liners before installation. Reject casings that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install casings in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Equipment Mounting:
 - 1. Where indicated on Drawings, install HVAC casings on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Apply sealant to joints, connections, and mountings.
- D. Field-cut openings for pipe and conduit penetrations through casing walls; insulate and seal in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- E. Seal all penetrations airtight. Cover with escutcheons and gaskets, or fill with suitable compound so there is no exposed insulation. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC." Provide shaft seals where fan shafts penetrate casing.
- F. Support casings on base or foundation system. Secure and seal to base.
- G. Support components rigidly with ties, braces, brackets, [**seismic restraints**], and anchors of types that will maintain housing shape and prevent buckling.
- H. Align casings accurately at connections, with **1/8-inch (3-mm)** misalignment tolerance and with smooth interior surfaces.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.

- B. Perform tests and inspections[**with the assistance of a shop-authorized service representative**].
- C. Tests and Inspections:
 - 1. Perform field tests of all fire dampers and control dampers, demonstrating that they open and close fully and without binding or excessive friction.
 - 2. Inspect all duct and casing access doors and other openings having movable covers, demonstrating that they are reasonably accessible, open and close fully without binding or excessive friction, and when fully closed, they seal properly.
 - 3. Perform field tests and inspections including air-duct leakage testing of supply-, return-, and exhaust-air ducts in accordance with SMACNA's "HVAC Air Duct Leakage Test Manual."
 - 4. Test the following systems:
 - a. Systems required by ASHRAE/IES 90.1.
 - b. Supply Air: [100][50]<Insert number> percent of total installed duct area with a pressure class of [3 (750)][4 (1000)]<Insert value> inch wg (Pa) or higher.
 - c. <Insert requirements of other systems>.
 - 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
 - 6. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirements for leakage classification of ducts connected to casings.
 - 7. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
- D. HVAC casings will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.4 CLEANING

- A. Comply with requirements for cleaning in Section 233113 "Metal Ducts."

END OF SECTION 23 31 00 00



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 31 13 00 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings - single wall.
2. Rectangular ducts and fittings - double wall.
3. Round ducts and fittings - single wall.
4. Round ducts and fittings - double wall.
5. Flat-oval ducts and fittings - single wall.
6. Flat-oval ducts and fittings - double wall.
7. Sheet metal materials.
8. Duct liner.
9. Sealants and gaskets.
10. Hangers and supports.
11. Strut support system for ductwork - metal, cable type.

B. Related Requirements:

1. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components.
2. Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraint devices and installation.
3. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
4. Section 233116 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
5. Section 233119.13 "Shop-Fabricated HVAC Casings" for field-fabricated casings for mechanical equipment.
6. Section 233119.16 "Manufactured HVAC Casings" for factory-fabricated casings for mechanical equipment.
7. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 DEFINITIONS

- A. OSHPD:** Office of Statewide Health Planning and Development (State of California).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top[**and bottom**] of ducts.
5. Dimensions of [main][all] duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment[, **seismic restraints**,] and vibration isolation.
13. **<Insert areas or systems requiring Shop Drawings>**.

C. Delegated Design Submittals:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations[, **including analysis data signed and sealed by the qualified professional engineer responsible for their preparation**] for selecting hangers and supports[**and seismic restraints**].

D. Sustainable Design Submittals:

1. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
3. Laboratory Test Reports:
 - a. For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
 - b. For antimicrobial coatings, indicating compliance with requirements for low-emitting materials.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Welding certificates.
- C. Field quality control reports.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.

3. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

1.6 MOCKUPS

- A. Before installing duct systems, build mockups representing static-pressure classes in excess of [3-inch wg (750 Pa)]<Insert static-pressure class>. Build mockups to comply with the following requirements, using materials indicated for the completed Work:
 1. [Five]<Insert number> transverse joints.
 2. [One]<Insert number> access door(s).
 3. [Two]<Insert number> typical branch connections, each with at least one elbow.
 4. [Two]<Insert number> typical flexible duct or flexible-connector connections for each duct and apparatus.
 5. [One]<Insert number> 90-degree turn(s) with turning vanes.
 6. [One]<Insert number> fire damper(s).
 7. [One]<Insert number> smoke damper(s).
 8. Perform leakage tests specified in "Field Quality Control" Article. Revise mockup construction and perform additional tests as required to achieve specified minimum acceptable results.
- B. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports[**and seismic restraints**] are to withstand the effects of gravity[**and seismic**] loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" [and][ASCE/SEI 7]<Insert applicable building code>. [Seismically brace duct hangers and supports in accordance with][SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."][SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems - OSHPD Edition."]<Insert reference document.>
 1. Seismic Hazard Level (SHL): [AA][A][B][C][D].
 2. Connection Level: [1][2].
 3. <Insert requirement>.
- C. Seismic Performance: Ductwork to withstand the effects of earthquake motions. See Section 018123 "Facility Seismic and Wind Criteria" that specifies basis-of-design seismic and wind criteria for nonstructural components. See Section 230548 "Vibration and Seismic Controls for HVAC."
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Component Importance Factor: [1.5][1.0].
 3. <Insert requirements for Component Amplification Factor and Component Response Modification Factor>.



- D. Wind-Restraint Performance: See Section 018123 "Facility Seismic and Wind Criteria" and Section 230548 "Vibration and Seismic Controls for HVAC" for building classification criteria.
- E. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.
- F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- G. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- H. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 RECTANGULAR DUCTS AND FITTINGS

A. Rectangular Ducts and Fittings - Single Wall:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ductmate Industries, Inc; a DMI company]**
 - b. **[McGill AirFlow LLC]**
 - c. **[MKT Metal Manufacturing]**
 - d. **[SHAPE Manufacturing Inc.]**
 - e. **[Sheet Metal Connectors, Inc.]**
 - f. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ductmate Industries, Inc; a DMI company]**
 - b. **[McGill AirFlow LLC]**
 - c. **[MKT Metal Manufacturing]**
 - d. **[SHAPE Manufacturing Inc.]**
 - e. **[Sheet Metal Connectors, Inc.]**
 - f. **<Insert manufacturer's name>**
- 3. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on static-pressure class indicated on the Drawings.
 - a. Construct ducts of **[galvanized sheet steel]<Insert material>**.
 - b. For ducts exposed to weather, construct of **[Type 304][Type 316]** stainless steel indicated by manufacturer in writing to be suitable for outdoor installation.
- 4. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. For ducts with longest side less than **36 inches (914 mm)**, select joint types in accordance

- with Figure 2-1.
- b. For ducts with longest side **36 inches (914 mm)** or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
 - c. Welded Transverse Joints:
 - 1) Provide all welded transverse joints for **<Insert specific systems or applications>**.
 - 2) See Drawings for specific systems or applications.
5. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." **[All longitudinal seams are to be Pittsburgh lock seams unless otherwise specified for specific application.]**
- a. Welded Longitudinal Seams:
 - 1) Provide all welded longitudinal seams for **<Insert specific systems or applications>**.
 - 2) See Drawings for specific systems or applications.
6. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Rectangular Ducts and Fittings - Double Wall:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ductmate Industries, Inc; a DMI company]**
 - b. **[McGill AirFlow LLC]**
 - c. **[MKT Metal Manufacturing]**
 - d. **[SHAPE Manufacturing Inc.]**
 - e. **[Sheet Metal Connectors, Inc.]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ductmate Industries, Inc; a DMI company]**
 - b. **[McGill AirFlow LLC]**
 - c. **[MKT Metal Manufacturing]**
 - d. **[SHAPE Manufacturing Inc.]**
 - e. **[Sheet Metal Connectors, Inc.]**
 - f. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain double-wall, rectangular ducts and fittings from single manufacturer.
 4. Rectangular Ducts: Fabricate ducts with indicated dimensions for clear internal dimensions of the inner duct.

5. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on static-pressure class indicated on the Drawings.
 - a. Construct ducts of **[galvanized sheet steel]<Insert material>**.
 - b. For ducts exposed to weather, construct outer duct of **[Type 304][Type 316]** stainless steel indicated by manufacturer in writing to be suitable for outdoor installation.
6. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. For ducts with longest side less than **36 inches (914 mm)**, select joint types in accordance with Figure 2-1.
 - b. For ducts with longest side **36 inches (914 mm)** or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
 - c. Welded Transverse Joints:
 - 1) Provide all welded transverse joints for **<Insert specific systems or applications>**.
 - 2) See Drawings for specific systems or applications.
7. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."**[All longitudinal seams are to be Pittsburgh lock seams unless otherwise specified for specific application.]**
 - a. Welded Longitudinal Seams:
 - 1) Provide all welded longitudinal seams for **<Insert specific systems or applications>**.
 - 2) See Drawings for specific systems or applications.
8. Interstitial Insulation, Fibrous Glass: Duct liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - a. Maximum Thermal Conductivity: **[0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)]<Insert conductivity>** at **75 deg F (24 deg C)** mean temperature.
 - b. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - c. Coat insulation with antimicrobial coating.
 - d. Cover insulation with polyester film complying with UL 181, Class 1.
9. Interstitial Insulation, Flexible Elastomeric: Duct liner complying with ASTM C534/C534M, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
 - a. Maximum Thermal Conductivity: **[0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K)]<Insert conductivity>** at **75 deg F (24 deg C)** mean temperature.
10. Inner Duct: Minimum **24-gauge (0.7-mm) [perforated galvanized sheet steel having 3/32-inch-(2.4-mm-) diameter perforations, with overall open area of 23 percent][solid galvanized sheet steel]**.

2.3 ROUND DUCTS AND FITTINGS

A. Round Ducts and Fittings - Single Wall:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Elgen Manufacturing]**
 - b. **[GreenSeam]**
 - c. **[Linx Industries; a DMI company (formerly Lindab)]**
 - d. **[McGill AirFlow LLC]**
 - e. **[MKT Metal Manufacturing]**
 - f. **[Nordfab Ducting]**
 - g. **[SEMCO, LLC; part of FlaktGroup]**
 - h. **[Set Duct Manufacturing]**
 - i. **[SHAPE Manufacturing Inc.]**
 - j. **[Sheet Metal Connectors, Inc.]**
 - k. **[Spiral Manufacturing Co., Inc.]**
 - l. **[Stamped Fittings Inc]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Elgen Manufacturing]**
 - b. **[GreenSeam]**
 - c. **[Linx Industries; a DMI company (formerly Lindab)]**
 - d. **[McGill AirFlow LLC]**
 - e. **[MKT Metal Manufacturing]**
 - f. **[Nordfab Ducting]**
 - g. **[SEMCO, LLC; part of FlaktGroup]**
 - h. **[Set Duct Manufacturing]**
 - i. **[SHAPE Manufacturing Inc.]**
 - j. **[Sheet Metal Connectors, Inc.]**
 - k. **[Spiral Manufacturing Co., Inc.]**
 - l. **[Stamped Fittings Inc]**
 - m. **<Insert manufacturer's name>**
3. Source Limitations: Obtain **[single-wall, round ducts and fittings][single-wall, round and flat-oval ducts and fittings]** from single manufacturer.
4. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class indicated on the Drawings.
 - a. Construct ducts of **[galvanized sheet steel]<Insert material>**.
 - b. For ducts exposed to weather, construct of **[Type 304][Type 316]** stainless steel indicated by manufacturer in writing to be suitable for outdoor installation.
5. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."



- a. Provide flanged joints for transverse joints in ducts larger than **[60 inches (1524 mm)]<Insert dimension>** in diameter.
 6. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Fabricate round ducts larger than **[90 inches (2286 mm)]<Insert dimension>** in diameter with butt-welded longitudinal seams.
 7. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Round Ducts and Fittings - Double Wall:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Linx Industries; a DMI company (formerly Lindab)]**
 - b. **[McGill AirFlow LLC]**
 - c. **[MKT Metal Manufacturing]**
 - d. **[SEMCO, LLC; part of FlaktGroup]**
 - e. **[Set Duct Manufacturing]**
 - f. **[SHAPE Manufacturing Inc.]**
 - g. **[Sheet Metal Connectors, Inc.]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Linx Industries; a DMI company (formerly Lindab)]**
 - b. **[McGill AirFlow LLC]**
 - c. **[MKT Metal Manufacturing]**
 - d. **[SEMCO, LLC; part of FlaktGroup]**
 - e. **[Set Duct Manufacturing]**
 - f. **[SHAPE Manufacturing Inc.]**
 - g. **[Sheet Metal Connectors, Inc.]**
 - h. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain **[double-wall, round ducts and fittings][double-wall, round and flat-oval ducts and fittings]** from single manufacturer.
 4. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class indicated on the Drawings.
 - a. Construct ducts of **[galvanized sheet steel]<Insert material>**.
 - b. For ducts exposed to weather, construct outer duct of **[Type 304][Type 316]** stainless steel indicated by manufacturer in writing to be suitable for outdoor installation.

- 1) Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a) Provide flanged joints for transverse joints in ducts larger than **[60 inches (1524 mm)]<Insert dimension>** in diameter.
- 2) Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a) Fabricate round ducts larger than **[90 inches (2286 mm)]<Insert dimension>** in diameter with butt-welded longitudinal seams.
- c. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
5. Inner Duct: Minimum **24-gauge (0.7-mm) [perforated galvanized sheet steel having 3/32-inch-(2.4-mm-) diameter perforations, with overall open area of 23 percent][solid galvanized sheet steel]**.
6. Interstitial Insulation, Fibrous Glass: Duct liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - a. Maximum Thermal Conductivity: **[0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)]<Insert conductivity>** at **75 deg F (24 deg C)** mean temperature.
 - b. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - c. Coat insulation with antimicrobial coating.
 - d. Cover insulation with polyester film complying with UL 181, Class 1.
7. Interstitial Insulation, Flexible Elastomeric: Duct liner complying with ASTM C534/C534M, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
 - a. Maximum Thermal Conductivity: **[0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K)]<Insert conductivity>** at **75 deg F (24 deg C)** mean temperature.

2.4 FLAT-OVAL DUCTS AND FITTINGS

A. Flat-Oval Ducts and Fittings - Single Wall:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Elgen Manufacturing]**
 - b. **[GreenSeam]**
 - c. **[Linx Industries; a DMI company (formerly Lindab)]**

- d. [McGill AirFlow LLC]
 - e. [MKT Metal Manufacturing]
 - f. [Nordfab Ducting]
 - g. [SEMCO, LLC; part of FlaktGroup]
 - h. [Set Duct Manufacturing]
 - i. [SHAPE Manufacturing Inc.]
 - j. [Sheet Metal Connectors, Inc.]
 - k. [Spiral Manufacturing Co., Inc.]
 - l. [Stamped Fittings Inc]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Elgen Manufacturing]
 - b. [GreenSeam]
 - c. [Linx Industries; a DMI company (formerly Lindab)]
 - d. [McGill AirFlow LLC]
 - e. [MKT Metal Manufacturing]
 - f. [Nordfab Ducting]
 - g. [SEMCO, LLC; part of FlaktGroup]
 - h. [Set Duct Manufacturing]
 - i. [SHAPE Manufacturing Inc.]
 - j. [Sheet Metal Connectors, Inc.]
 - k. [Spiral Manufacturing Co., Inc.]
 - l. [Stamped Fittings Inc]
 - m. <Insert manufacturer's name>
3. Source Limitations: Obtain [single-wall, flat-oval ducts and fittings][single-wall, flat-oval and round ducts and fittings] from single manufacturer.
4. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class indicated on the Drawings.
- a. Construct ducts of [galvanized sheet steel]<Insert material>.
 - b. For ducts exposed to weather, construct of [Type 304][Type 316] stainless steel indicated by manufacturer in writing to be suitable for outdoor installation.
 - c. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1) Provide flanged joints for transverse joints in ducts larger than [60 inches (1524 mm)]<Insert dimension> in diameter.
5. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
 - b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with

butt-welded longitudinal seams.

6. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Flat-Oval Ducts and Fittings - Double Wall:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Linx Industries; a DMI company (formerly Lindab)]**
 - b. **[McGill AirFlow LLC]**
 - c. **[MKT Metal Manufacturing]**
 - d. **[SEMCO, LLC; part of FlaktGroup]**
 - e. **[Set Duct Manufacturing]**
 - f. **[SHAPE Manufacturing Inc.]**
 - g. **[Sheet Metal Connectors, Inc.]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Linx Industries; a DMI company (formerly Lindab)]**
 - b. **[McGill AirFlow LLC]**
 - c. **[MKT Metal Manufacturing]**
 - d. **[SEMCO, LLC; part of FlaktGroup]**
 - e. **[Set Duct Manufacturing]**
 - f. **[SHAPE Manufacturing Inc.]**
 - g. **[Sheet Metal Connectors, Inc.]**
 - h. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain **[double-wall, flat-oval ducts and fittings][double-wall, flat-oval and round ducts and fittings]** from single manufacturer.
 4. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class indicated on the Drawings.
 - a. Construct ducts of **[galvanized sheet steel]<Insert material>**.
 - b. For ducts exposed to weather, construct outer duct of **[Type 304][Type 316]** stainless steel indicated by manufacturer in writing to be suitable for outdoor installation.
 - c. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1) Provide flanged joints for transverse joints in ducts larger than **[60 inches (1524 mm)]<Insert dimension>** in diameter.
 - d. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's

"HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- 1) Fabricate flat-oval ducts larger than **[72 inches (1830 mm) in width (major dimension)]<Insert dimension>** with butt-welded longitudinal seams.
- e. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
5. Inner Duct: Minimum **24-gauge (0.7-mm) [perforated galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent][solid galvanized sheet steel]**.
6. Interstitial Insulation, Fibrous Glass: Duct liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - a. Maximum Thermal Conductivity: **[0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)]<Insert conductivity>** at **75 deg F (24 deg C)** mean temperature.
 - b. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - c. Coat insulation with antimicrobial coating.
 - d. Cover insulation with polyester film complying with UL 181, Class 1.
7. Interstitial Insulation, Flexible Elastomeric: Duct liner complying with ASTM C534/C534M, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
 - a. Maximum Thermal Conductivity: **[0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K)]<Insert conductivity>** at **75 deg F (24 deg C)** mean temperature.

2.5 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods. Sheet metal materials are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 1. Galvanized Coating Designation: **[G60 (Z180)][G90 (Z275)]**.
 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
 3. Lockforming Quality: Sheet steel and galvanized coating is to be able to be formed with back-to-back bends in seams such as the Pittsburgh lock at high speed without cracking or flaking of the coating on the outside of the bend.
- C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 1. Galvanized Coating Designation: **[G60 (Z180)][G90 (Z275)]**.
 2. Minimum Thickness for Factory-Applied PVC Coating: **4 mils (0.10 mm) thick[on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil (0.025 mm) thick on opposite surface]**.

3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.
- D. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.
- E. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish is to be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.
- F. Aluminum Sheets: Comply with **ASTM B209 (ASTM B209M)** Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- G. Factory- or Shop-Applied Antimicrobial Coating:
 1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating is to be applied to the exterior surface.
 2. Antimicrobial compound is to be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 3. Coating containing the antimicrobial compound is to have a hardness of 2H, minimum, when tested in accordance with ASTM D3363.
 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
 5. Shop-Applied Coating Color: **[Black][White]**.
 6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
- H. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- I. Tie Rods: Galvanized steel, **1/4-inch- (6-mm-)** minimum diameter for lengths **36 inches (900 mm)** or less; **3/8-inch- (10-mm-)** minimum diameter for lengths longer than **36 inches (900 mm)**.

2.6 DUCT LINER

- A. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[CertainTeed; SAINT-GOBAIN]**
 - b. **[Johns Manville; a Berkshire Hathaway company]**
 - c. **[Knauf Insulation]**
 - d. **[Owens Corning]**
 - e. **[Sekisui Voltek, LLC]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [CertainTeed; SAINT-GOBAIN]
 - b. [Johns Manville; a Berkshire Hathaway company]
 - c. [Knauf Insulation]
 - d. [Owens Corning]
 - e. [Sekisui Voltek, LLC]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain fibrous-glass duct liner from single manufacturer.
4. Maximum Thermal Conductivity:
 - a. Type I, Flexible: [0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)]<Insert conductivity> at 75 deg F (24 deg C) mean temperature.
 - b. Type II, Rigid: [0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K)]<Insert conductivity> at 75 deg F (24 deg C) mean temperature.
5. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound is to be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
6. Liner Adhesive: [Solvent][Water]-based liner adhesive, complying with NFPA 90A or NFPA 90B and with ASTM C916.
 - a. Adhesive: As recommended by adhesive manufacturer and with a VOC content of 80 g/L or less.
 - 1) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 2) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - 3) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.
- B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Aeroflex USA]
 - b. [Armacell LLC]
 - c. [K-Flex USA]
 - d. [Sekisui Voltek, LLC]
 - e. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aeroflex USA]**
 - b. **[Armacell LLC]**
 - c. **[K-Flex USA]**
 - d. **[Sekisui Voltek, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain flexible elastomeric duct liner from single manufacturer.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
5. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - a. Adhesive: As recommended by adhesive manufacturer and with a VOC content of 80 g/L or less.
 - 1) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 2) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - 3) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.
- C. Fibrous-Glass-Free, Natural-Fiber Duct Liner: Made from partially recycled cotton or polyester products and containing no fiberglass. Airstream surface overlaid with fire-resistant facing to prevent surface erosion by airstream, complying with NFPA 90A or NFPA 90B. Treat natural-fiber products with antimicrobial coating.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Acoustical Surfaces, Inc.]**
 - b. **[Ductmate Industries, Inc; a DMI company]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acoustical Surfaces, Inc.]**
 - b. **[Ductmate Industries, Inc; a DMI company]**
 - c. **<Insert manufacturer's name>**

3. Source Limitations: Obtain fibrous-glass-free, natural-fiber duct liner from single manufacturer.
 4. Maximum Thermal Conductivity: **[0.24 Btu x in./h x sq. ft. x deg F (0.034 W/m x K)]<Insert conductivity> at 75 deg F (24 deg C)** mean temperature when tested in accordance with ASTM C518.
 5. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with ASTM E84; certified by an NRTL.
 6. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - a. Adhesive: As recommended by adhesive manufacturer and with a VOC content of 80 g/L or less.
 - 1) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 2) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - 3) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.
- D. Polyolefin Duct Liner: Cross-linked, partially open-cell polyolefin foam sheet or roll materials, with reinforced aluminum foil facing and adhesive backing, complying with NFPA 90A or NFPA 90B; sheet (Type II) complying with ASTM C1427.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Sekisui Voltek, LLC]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Sekisui Voltek, LLC]**
 - b. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain polyolefin duct liner from single manufacturer.
 4. Foam Core Density: **1.5 pcf (25 kg/cm)**.
 5. Maximum Thermal Conductivity: **[0.25 Btu x in./h x sq. ft. x deg F (0.036 W/m x K)]<Insert conductivity> at 75 deg F (24 deg C)** mean temperature when tested in accordance with ASTM C518.
 6. Minimum Noise Reduction Coefficient (NRC): 0.50 for **3/8-inch (10-mm)** thickness, 0.45 for **5/8-inch (15-mm)** thickness, 0.55 for **1-inch (24-mm)** thickness, and 0.55 for **2-1/8-inch (54-mm)** thickness.

7. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
 8. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - a. Adhesive: As recommended by adhesive manufacturer and with a VOC content of 80 g/L or less.
 - 1) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 2) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - 3) Verify adhesive complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.
- E. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, **[0.106-inch- (2.6-mm-)]****[0.135-inch- (3.5-mm-)]** diameter shank, length to suit depth of insulation indicated with integral **1-1/2-inch (38-mm)** galvanized carbon-steel washer.
 2. Insulation-Retaining Washers: Self-locking washers formed from **0.016-inch- (0.41-mm-)** thick **[galvanized steel]****[aluminum]****[stainless steel]**; with beveled edge sized as required to hold insulation securely in place, but not less than **1-1/2 inches (38 mm)** in diameter.
- F. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
 2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 3. Butt transverse joints without gaps, and coat joint with adhesive.
 4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
 5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
 6. Apply adhesive coating on longitudinal seams in ducts with air velocity of **2500 fpm (12.7 m/s)** or greater.
 7. Secure liner with mechanical fasteners **4 inches (100 mm)** from corners and at intervals not exceeding **12 inches (300 mm)** transversely; at **3 inches (75 mm)** from transverse joints and at intervals not exceeding **18 inches (450 mm)** longitudinally.
 8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.

- b. Intervals of lined duct preceding unlined duct.
 - c. Upstream edges of transverse joints in ducts where air velocities are higher than **[2500 fpm (12.7 m/s)]<Insert velocity>**.
9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
- a. Sheet Metal Inner Duct Perforations: **3/32-inch (2.4-mm)** diameter, with an overall open area of 23 percent.
10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.7 SEALANTS AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets are to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
- 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 - 2. Tape Width: **[3 inches (76 mm)][4 inches (100 mm)][6 inches (152 mm)]**.
 - 3. Sealant: Modified styrene acrylic.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. Maximum Static-Pressure Class: **10-inch wg (2500 Pa)**, positive and negative.
 - 7. Service: Indoor and outdoor.
 - 8. Service Temperature: **Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C)**.
 - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
 - 10. Sealant shall have a VOC content of 420 g/L or less.
- a. Verify sealant complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - b. Verify sealant complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - c. Verify sealant complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.
- C. Water-Based Joint and Seam Sealant:
- 1. Application Method: Brush on.
 - 2. Solids Content: Minimum 65 percent.
 - 3. Shore A Hardness: Minimum 20.

4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: **10-inch wg (2500 Pa)**, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Maximum Static-Pressure Class: **10-inch wg (2500 Pa)**, positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
11. Sealant shall have a VOC content of 420 g/L or less.
12. Verify sealant complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
13. Verify sealant complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
14. Verify sealant complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.

E. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single component, acid curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Verify sealant complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
8. Verify sealant complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
9. Verify sealant complies with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify the building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.



- F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- G. Round Duct Joint O-Ring Seals:
 - 1. Seal is to provide maximum leakage class of **3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa)** and is to be rated for **10-inch wg (2500 Pa)** static-pressure class, positive or negative.
 - 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 - 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.8 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," **Table 5-1 (Table 5-1M)**, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.
- E. Steel Cables for Stainless Steel Ducts: Stainless steel complying with ASTM A492.
- F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.
- I. Strut Support System for Ductwork - Metal, Cable Type:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[CADDY; brand of nVent Electrical plc]**
 - b. **[Gripple Inc.]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[CADDY; brand of nVent Electrical plc]**
- b. **[Gripple Inc.]**
- c. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain metal cable type strut support system for ductwork from single manufacturer.
- 4. Description: Factory-fabricated ductwork support system consisting of cable clamps, slotted channel brackets, wire-rope suspension components, and associated accessories for a complete ductwork suspension system. No tools required for manual assembly in the field to support ductwork routing.
- 5. Components:
 - a. Brackets: Slotted steel channels furnished in pre-cut lengths to suit specific system application for Project.
 - b. Suspension Components: Hanging cables with adjustable fasteners.
 - 1) Wire Rope: High-tensile-steel wire rope, complying with **ASTM A1023 (ASTM 1023M)**; lengths, diameters, and wire construction **[to accommodate design loads][indicated on Shop Drawings]**.
 - a) Foot attachment type to suit application.
 - b) End Fix Type: **[Loop][, strap hook][, eyelet][or]<Insert fix type><as required to suit application>**.

PART 3 - EXECUTION

3.1 INSTALLATION OF DUCTS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.
- B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Install ducts in maximum practical lengths with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of **1 inch (25 mm)**, plus allowance for insulation thickness.
- H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same

metal thickness as the duct. Overlap openings on four sides by at least **1-1/2 inches (38 mm)**.

- J. Install fire[, **combination fire/smoke,**] and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.
- K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. [**Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."**]
- M. Elbows: Use long-radius elbows wherever they fit.
 - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 - 2. Fabricate 90-degree round elbows with a minimum of three segments for **12 inches (300 mm)** and smaller and a minimum of five segments for **14 inches (350 mm)** and larger.
- N. Branch Connections: Use lateral or conical branch connections.
- O. Installation of Metal, Cable-Type Strut Support System for Ductwork: Install in accordance with manufacturer's written installation instructions.

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR TYPE 1 COMMERCIAL KITCHEN GREASE HOOD EXHAUST DUCT

- A. Install ducts in accordance with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operation"; SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; and SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines."
- B. Install all ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

- C. All ducts exposed to view are to be constructed of stainless steel as per "Duct Schedule" Article. All ducts concealed from view are to be [~~stainless~~][~~carbon~~] steel as per "Duct Schedule" Article.
 - D. All joints are to be welded and are to be telescoping, bell, or flange joint as per NFPA 96.
 - E. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of [20 ft. (6 m)][12 ft. (3.7 m)]<Insert dimension> in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings.
 - F. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.
- 3.4 ADDITIONAL INSTALLATION REQUIREMENTS FOR EXHAUST DUCTS SERVING COMMERCIAL DISHWASHERS AND OTHER HIGH-HUMIDITY LOCATIONS
- A. Install dishwasher exhaust ducts and other exhaust ducts from wet, high-humidity locations without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to dishwasher or toward drain.
 - B. Provide a drain pocket at each low point and at the base of each riser with a 1-inch (25-mm) trapped copper drain from each drain pocket to open-sight floor drain.
 - C. Minimize number of transverse seams.
 - D. Do not locate longitudinal seams on bottom of duct.
- 3.5 ADDITIONAL INSTALLATION REQUIREMENTS FOR LABORATORY EXHAUST AND FUME HOOD EXHAUST DUCTS
- A. Install ducts in accordance with NFPA 45, "Fire Protection for Laboratories Using Chemicals."
 - B. Install exhaust ducts without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to hood or inlet. Where indicated on Drawings, install trapped drain piping.
 - C. Connect duct to fan, fume hood, and other equipment indicated on Drawings.
- 3.6 REQUIREMENTS FOR DUCTWORK EXPOSED TO WEATHER
- A. All external joints are to [~~be welded~~][have secure watertight mechanical connections]. Seal all openings to provide weatherproof construction.
 - B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.
 - C. Single Wall:
 - 1. Ductwork is to be [~~Type 304~~][Type 316] stainless steel.
 - 2. Ductwork is to be galvanized steel.
 - a. If duct outer surface is uninsulated, protect outer surface with suitable paint. Paint materials and application requirements are specified in Section 099113 "Exterior Painting."
 - 3. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section

230713 "Duct Insulation."

D. Double Wall:

1. Ductwork is to comply with requirements in "Rectangular Ducts and Fittings - Double Wall," "Round Ducts and Fittings - Double Wall," or "Flat-Oval Ducts and Fittings - Double Wall" Product Type.
2. Ductwork outer wall is to be **[Type 304][Type 316]** stainless steel indicated by manufacturer in writing to be suitable for outdoor installation.
3. Provide interstitial insulation as specified under Part 2.

3.7 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher than 2-Inch wg (500 Pa): Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher than 2-Inch wg (500 Pa): Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.8 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than **4 inches (100 mm)** thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than **4 inches (100 mm)** thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," **Table 5-1 (Table 5-1M)**, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within **24 inches (610 mm)** of each elbow and within **48 inches (1220 mm)** of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of **16 ft. (5 m)**.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.9 INSTALLATION OF SEISMIC-RESTRAINT DEVICES

- A. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraint installation requirements.

3.10 DUCTWORK CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.11 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.12 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Test the following systems:
 - a. Ducts with a Pressure Class Higher than 3-Inch wg (750 Pa): Test representative duct sections[, **selected by Architect from sections installed,**] totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - b. Supply Ducts: For pressure class of [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert number> or higher; test representative duct sections[, **selected by Architect from sections installed,**] totaling no less than [50][100]<Insert number> percent of total installed duct area for each designated pressure class.
 - c. Return Ducts: For a pressure class of [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg

(1000 Pa)]<Insert number> or higher; test representative duct sections[, **selected by Architect from sections installed,**] totaling no less than [50][100]<Insert number> percent of total installed duct area for each designated pressure class.

- d. Exhaust Ducts: For a pressure class of [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert number> or higher; test representative duct sections[, **selected by Architect from sections installed,**] totaling no less than [50][100]<Insert number> percent of total installed duct area for each designated pressure class.
- e. Outdoor-Air Ducts: For a pressure class of [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert number> or higher; test representative duct sections[, **selected by Architect from sections installed,**] totaling no less than [50][100]<Insert number> percent of total installed duct area for each designated pressure class.

- 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
- 4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
- 5. Test for leaks before applying external insulation.
- 6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
- 7. Give [seven]<Insert number> days' advance notice for testing.

C. Duct System Cleanliness Tests:

- 1. Visually inspect duct system to ensure that no visible contaminants are present.
- 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning, and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.13 DUCT CLEANING

- A.** Clean new duct system(s) before testing, adjusting, and balancing.
- B.** For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."
- C.** Use duct cleaning methodology as indicated in NADCA ACR.
- D.** Use service openings for entry and inspection.
 - 1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.

3. Remove and reinstall ceiling to gain access during the cleaning process.

E. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

F. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

G. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.14 STARTUP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.15 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

2. Underground Ducts: Concrete-encased, **[galvanized sheet steel][PVC-coated, galvanized sheet steel with thicker coating on duct exterior][stainless steel]**.
3. **<Insert requirements>**.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units: **<Insert equipment>**.
 - a. Pressure Class: Positive **[1-inch wg (250 Pa)][2-inch wg (500 Pa)]<Insert number>**.
 - b. Minimum SMACNA Seal Class: **[A][B][C]**.
 - c. SMACNA Leakage Class for Rectangular: **[2][4][8][16]**.
 - d. SMACNA Leakage Class for Round and Flat Oval: **[2][4][8][16]**.
2. Ducts Connected to Constant-Volume Air-Handling Units: **<Insert equipment>**.
 - a. Pressure Class: Positive **[2-inch wg (500 Pa)][3-inch wg (750 Pa)]<Insert number>**.
 - b. Minimum SMACNA Seal Class: **[A][B]**.
 - c. SMACNA Leakage Class for Rectangular: **[2][4][8][16]**.
 - d. SMACNA Leakage Class for Round and Flat Oval: **[2][4][8][16]**.
3. Ducts Connected to Variable-Air-Volume Air-Handling Units: **<Insert equipment>**.
 - a. Pressure Class: Positive **[3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert number>**.
 - b. Minimum SMACNA Seal Class: **[A][B]**.
 - c. SMACNA Leakage Class for Rectangular: **[2][4][8][16]**.
 - d. SMACNA Leakage Class for Round and Flat Oval: **[2][4][8][16]**.
4. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive **[2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert number>**.
 - b. Minimum SMACNA Seal Class: **[A][B][C]**.
 - c. SMACNA Leakage Class for Rectangular: **[2][4][8][16]**.
 - d. SMACNA Leakage Class for Round and Flat Oval: **[2][4][8][16]**.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units: **<Insert equipment>**.
 - a. Pressure Class: Positive or negative **[1-inch wg (250 Pa)][2-inch wg (500 Pa)]<Insert number>**.
 - b. Minimum SMACNA Seal Class: **[A][B][C]**.
 - c. SMACNA Leakage Class for Rectangular: **[2][4][8][16]**.
 - d. SMACNA Leakage Class for Round and Flat Oval: **[2][4][8][16]**.
2. Ducts Connected to Air-Handling Units: **<Insert equipment>**.
 - a. Pressure Class: Positive or negative **[2-inch wg (500 Pa)][3-inch wg (750 Pa)]<Insert number>**.
 - b. Minimum SMACNA Seal Class: **[A][B][C]**.
 - c. SMACNA Leakage Class for Rectangular: **[2][4][8][16]**.
 - d. SMACNA Leakage Class for Round and Flat Oval: **[2][4][8][16]**.

3. Ducts Connected to Equipment Not Listed Above:
- Pressure Class: Positive or negative [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert number>.
 - Minimum SMACNA Seal Class: [A][B][C].
 - SMACNA Leakage Class for Rectangular: [2][4][8][16].
 - SMACNA Leakage Class for Round and Flat Oval: [2][4][8][16].

D. Exhaust Ducts:

- Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - Pressure Class: Negative [1-inch wg (250 Pa)][2-inch wg (500 Pa)][3-inch wg (750 Pa)]<Insert number>.
 - Minimum SMACNA Seal Class: [A][B][C] if negative pressure, and A if positive pressure.
 - SMACNA Leakage Class for Rectangular: [2][4][8][16].
 - SMACNA Leakage Class for Round and Flat Oval: [2][4][8][16].
- Ducts Connected to Air-Handling Units: <Insert equipment>.
 - Pressure Class: Positive or negative [2-inch wg (500 Pa)][3-inch wg (750 Pa)]<Insert number>.
 - Minimum SMACNA Seal Class: [A][B][C] if negative pressure, and [A][B][C] if positive pressure.
 - SMACNA Leakage Class for Rectangular: [2][4][8][16].
 - SMACNA Leakage Class for Round and Flat Oval: [2][4][8][16].
- Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.
 - Exposed to View: Type 304, stainless steel sheet, [No. 4][No. 3]<Insert finish> finish.
 - Concealed: [Type 304, stainless steel sheet, No. 2D finish][Carbon-steel sheet].
 - Welded seams and joints.
 - Pressure Class: Positive or negative [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert number>.
 - Airtight/watertight.
- Ducts Connected to Dishwashers, Dishwasher Hoods, and Other High-Humidity Locations:
 - Type 304, stainless steel sheet.
 - Exposed to View: [No. 4][No. 3]<Insert finish> finish.
 - Concealed: [No. 2D]<Insert finish> finish.
 - Welded longitudinal seams; welded or flanged transverse joints with watertight EPDM gaskets.
 - Pressure Class: Positive or negative [2-inch wg (500 Pa)][3-inch wg (750 Pa)]<Insert number>.
 - Airtight/watertight.
- Ducts Connected to Fans Exhausting Fume Hood, Laboratory, and Process (ASHRAE 62.1, Class 3 and Class 4) Air:
 - [Type 316][Type 304], stainless steel sheet.
 - Exposed to View: [No. 4][No. 3]<Insert finish> finish.
 - Concealed: [No. 2B][No. 2D]<Insert finish> finish.
 - PVC-coated, galvanized sheet steel with thicker coating on duct interior.

- c. Pressure Class: Positive or negative [3-inch wg (750 Pa)][4-inch wg (1000 Pa)][6-inch wg (1500 Pa)]<Insert number>.
- d. Seal Class: [Minimum SMACNA Seal Class A]<Insert seal class>.
- e. Joints: [Welded seams and joints, airtight/watertight]<Insert seam and joint types>.
- f. Leakage Class: [SMACNA Leakage Class 2]<Insert leakage class>.

6. Ducts Connected to Equipment Not Listed above:

- a. Pressure Class: Positive or negative [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert number>.
- b. Minimum SMACNA Seal Class: [A][B] if negative pressure; A if positive pressure.
- c. SMACNA Leakage Class for Rectangular: [2][4][8][16].
- d. SMACNA Leakage Class for Round and Flat Oval: [2][4][8][16].

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units <Insert equipment>:

- a. Pressure Class: Positive or negative [1-inch wg (250 Pa)][2-inch wg (500 Pa)]<Insert number>.
- b. Minimum SMACNA Seal Class: [A][B][C].
- c. SMACNA Leakage Class for Rectangular: [8][16].
- d. SMACNA Leakage Class for Round and Flat Oval: [8][16].

2. Ducts Connected to Air-Handling Units <Insert equipment>:

- a. Pressure Class: Positive or negative [2-inch wg (500 Pa)][3-inch wg (750 Pa)]<Insert number>.
- b. Minimum SMACNA Seal Class: [A][B].
- c. SMACNA Leakage Class for Rectangular: [2][4][8][16].
- d. SMACNA Leakage Class for Round and Flat Oval: [2][4][8][16].

3. Ducts Connected to Equipment Not Listed Above:

- a. Pressure Class: Positive or negative [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert number>.
- b. Minimum SMACNA Seal Class: [A][B].
- c. SMACNA Leakage Class for Rectangular: [2][4][8][16].
- d. SMACNA Leakage Class for Round and Flat Oval: [2][4][8][16].

F. Intermediate Reinforcement:

- 1. Galvanized-Steel Ducts: [Galvanized steel][Carbon steel coated with zinc-chromate primer][Galvanized steel or carbon steel coated with zinc-chromate primer].
- 2. PVC-Coated Ducts:

- a. Exposed to Airstream: Match duct material.
- b. Not Exposed to Airstream: [Galvanized][Match duct material].

3. Stainless Steel Ducts:

- a. Exposed to Airstream: Match duct material.
- b. Not Exposed to Airstream: [Galvanized][Match duct material].

4. Aluminum Ducts: **[Aluminum][or][galvanized steel coated with zinc chromate].**

G. Liner:

1. Supply-Air Ducts: **[Fibrous glass, Type I][Flexible elastomeric][Fibrous-glass-free, natural fiber][Polyolefin], [5/8 inch (15 mm)][1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (51 mm)]<Insert dimension> thick.**
2. Return-Air Ducts: **[Fibrous glass, Type I][Flexible elastomeric][Fibrous-glass-free, natural fiber][Polyolefin], [5/8 inch (15 mm)][1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (51 mm)]<Insert dimension> thick.**
3. Exhaust-Air Ducts: **[Fibrous glass, Type I][Flexible elastomeric][Fibrous-glass-free, natural fiber][Polyolefin], [5/8 inch (15 mm)][1 inch (25 mm)]<Insert dimension> thick.**
4. Supply Fan Plenums: **[Fibrous glass, Type II][Flexible elastomeric][Fibrous-glass-free, natural fiber][Polyolefin], [5/8 inch (15 mm)][1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (51 mm)]<Insert dimension> thick.**
5. Return- and Exhaust-Fan Plenums: **[Fibrous glass, Type II][Flexible elastomeric][Fiberglass-free, natural fiber][Polyolefin], [5/8 inch (15 mm)][1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (51 mm)]<Insert dimension> thick.**
6. Transfer Ducts: **[Fibrous glass, Type I][Flexible elastomeric][Fibrous-glass-free, natural fiber][Polyolefin], [5/8 inch (15 mm)][1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (51 mm)]<Insert dimension> thick.**

H. Double-Wall Duct Interstitial Insulation:

1. Supply-Air Ducts: **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (51 mm)]<Insert dimension> thick.**
2. Return-Air Ducts: **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (51 mm)]<Insert dimension> thick.**
3. Exhaust-Air Ducts: **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (51 mm)]<Insert dimension> thick.**

I. Elbow Configuration:

1. Rectangular Duct - Requirements for Different Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm (5 m/s) or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm (7.6 m/s) or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."



2. Rectangular Duct - Requirements for All Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to-Diameter Ratio: 1.5.
 - b. Round Elbows:
 - 1) Stamped or pleated for [12 inches (305 mm)]<Insert dimension> and smaller diameters.
 - 2) Standing seam for [14 inches (356 mm)]<Insert dimension> and larger diameter.
 - 3) Welded for [14 inches (356 mm)]<Insert dimension> and larger diameter.
- J. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Conical spin in.
 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
 - c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 23 31 13 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 31 13 00	23 31 00 00	Shop-Fabricated HVAC Casings
23 31 13 13	23 31 13 00	Metal Ducts
23 31 13 13	23 31 00 00	Shop-Fabricated HVAC Casings
23 31 13 16	23 31 13 00	Metal Ducts
23 31 13 16	23 31 00 00	Shop-Fabricated HVAC Casings
23 31 13 19	23 31 13 00	Metal Ducts
23 31 13 19	23 31 00 00	Shop-Fabricated HVAC Casings
23 31 13 19	23 33 00 00	Air Duct Accessories
23 31 13 23	23 31 13 00	Metal Ducts
23 31 13 23	23 31 00 00	Shop-Fabricated HVAC Casings



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 31 16 00 - NONMETAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fibrous-glass ducts and fittings.
2. Phenolic-foam ducts and fittings.
3. Thermoset FRP ducts and fittings.
4. PVC ducts and fittings.
5. CPVC ducts and fittings.
6. HDPE duct and fittings.

B. Related Requirements:

1. Section 230130.52 "Existing HVAC Air-Distribution System Cleaning" for cleaning of existing HVAC air-distribution equipment, ducts, plenums, and system components.
2. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration-isolated and restrained ductwork hangers and supports.
3. Section 230548.13 "Vibration Controls for HVAC" for vibration-isolated ductwork and hangers.
4. Section 233113 "Metal Ducts" for single- and double-wall, rectangular and round ducts.
5. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Fibrous-glass duct materials.
2. Phenolic-foam duct materials.
3. Thermoset FRP duct materials.
4. PVC duct materials.
5. CPVC duct materials.
6. HDPE duct materials.

B. Sustainable Design Submittals:

1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Product Data: For adhesives, indicating VOC content.
4. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
5. Product Data: For sealants, indicating VOC content.
6. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes and pressure classes.
3. Elevation of top of ducts.
4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated, smoke-rated, and other partitions.
9. Fire and smoke damper locations.
10. Equipment installation based on equipment being used on Project.
11. Hangers and supports, including methods for duct and building attachment[, **seismic restraints,**] and vibration isolation.

D. Delegated-Design Submittal: For nonmetal ducts, signed and sealed by a qualified professional engineer.

1. Duct materials and thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports[**and seismic restraints**].
5. Design calculations for selecting hangers and supports[**and seismic restraints**].[**Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.**]

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.
- B. Seismic Qualification Data: Certificates, for nonmetal ducts, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Welding certificates.
- D. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Hanger and Support Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for steel hangers and supports.
 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum hangers and supports.
- B. Mockups:

1. Before installing duct systems, build mockups representing static-pressure classes [3-inch wg (750 Pa)]<Insert value> and higher. Build mockups to comply with the following requirements, using materials indicated for the completed Work:
 - a. [Five]<Insert number> transverse joints.
 - b. [One]<Insert number> access door(s).
 - c. [Two]<Insert number> typical branch connections, each with at least one elbow.
 - d. [Two]<Insert number> typical flexible duct or flexible-connector connections for each duct and apparatus.
 - e. [One]<Insert number> 90-degree turn(s) with turning vanes.
 - f. [One]<Insert number> fire damper(s).
 - g. [One]<Insert number> smoke damper(s).
 - h. Perform leakage tests specified in "Field Quality Control" Article. Revise mockup construction and perform additional tests as required to achieve specified minimum acceptable results.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of ductwork system that fail in material or workmanship within specified warranty period.
 1. Warranty Period, HDPE Duct System: [10]<Insert number> year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including duct closure, reinforcements, and hangers and supports, shall comply with the following and with the Works' performance requirements and design criteria:
 1. SMACNA's "Fibrous Glass Duct Construction Standards."
 2. SMACNA's "Phenolic Duct Construction Standards."
 3. SMACNA's "Thermoplastic Duct (PVC) Construction Manual."
 4. SMACNA's "Thermoset FRP Duct Construction Manual."
 5. Static-Pressure Classes:
 - a. Supply Ducts (except in Mechanical Rooms): [2-inch wg (500 Pa)]<Insert value>.
 - b. Supply Ducts (Upstream from Air Terminal Units): [2-inch wg (500 Pa)]<Insert value>.
 - c. Supply Ducts (Downstream from Air Terminal Units): [1-inch wg (250 Pa)]<Insert value>.
 - d. Supply Ducts (in Mechanical Equipment Rooms): [2-inch wg (500 Pa)]<Insert value>.
 - e. Return Ducts (Negative Pressure): [1-inch wg (250 Pa)]<Insert value>.
 - f. Exhaust Ducts (Negative Pressure): [1-inch wg (250 Pa)]<Insert value>.
 - g. <Insert duct systems and static-pressure class>.
- B. Seismic Performance: Ducts to withstand the effects of earthquake motions determined in accordance with [ASCE/SEI 7]<Insert requirement>. See Section 230548 "Vibration and Seismic Controls for HVAC."



1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
2. Component Importance Factor: **[1.5][1.0]**.
3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

C. Wind-Restraint Performance:

1. See **[Section 230548 "Vibration and Seismic Controls for HVAC"]****[Section 230548.13 "Vibration Controls for HVAC"]** for requirements.

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1, Section 5.4 - "Airstream Surfaces."

E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

F. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

G. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

2.2 FIBROUS-GLASS DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[CertainTeed; SAINT-GOBAIN]**
2. **[Johns Manville; a Berkshire Hathaway company]**
3. **[Knauf Insulation]**
4. **[Owens Corning]**
5. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[CertainTeed; SAINT-GOBAIN]**
2. **[Johns Manville; a Berkshire Hathaway company]**
3. **[Knauf Insulation]**
4. **[Owens Corning]**
5. **<Insert manufacturer's name>**

C. Fibrous-Glass Duct Materials: Resin-bonded fiberglass, faced on the outside surface with fire-resistive FSK vapor retarder and with a smooth fiberglass mat finish on the air-side surface.

1. Duct Board: Factory molded into rectangular boards.
2. Temperature Limits: **40 to 250 deg F (5 to 121 deg C)** inside ducts; **150 deg F (66 deg C)** ambient temperature surrounding ducts.
3. Maximum Thermal Conductivity: **[0.24 Btu x in./h x sq. ft. x deg F (0.035 W/m x K)]****<Insert**

conductivity> at **75 deg F (24 deg C)** mean temperature.

4. Moisture Absorption: Not exceeding 5 percent by weight at **120 deg F (49 deg C)** and 95 percent relative humidity for 96 hours when tested according to ASTM C1104/C1104M.
5. Acoustical Performance: Conform to sound absorption coefficients listed in NAIMA AH116.
6. Permeability: **0.02 perm (1.15 ng/Pa x s x sq. m)** maximum when tested according to ASTM E96/E96M, Procedure A.
7. Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL, and registered by the EPA for use in HVAC systems.
8. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C423, Mounting A.
9. Fire/Smoke Resistance: Duct material shall comply with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E84.
10. Required Markings: EI stiffness rating, UL label, and other markings required by UL 181 on each full sheet of duct board.

D. Closure Materials:

1. Pressure-Sensitive Tape: Comply with UL 181A; imprinted by manufacturer with coding "181A-P," manufacturer's name, and a date code.
 - a. Tape: Aluminum foil-scrim tape imprinted with listing information.
 - b. Minimum Tape Width: **2-1/2 inches (64 mm); 3 inches (76 mm)** for duct board thicker than **1 inch (25 mm)**.
 - c. Staples: **1/2-inch (13-mm)** outward clinching, **2 inches (51 mm)** o.c. in tabs, one tab per joint.
 - d. Water resistant.
 - e. Mold and mildew resistant.
2. Heat-Activated Tape: Comply with UL 181A; imprinted by manufacturer with coding "181A-H," manufacturer's name, and a date code.
 - a. Tape: Aluminum foil-scrim tape imprinted with listing information.
 - b. Minimum Tape Width: **3 inches (76 mm)**.
 - c. Heat-Sensitive Imprint: Printed indicator on tape to show proper heating during application has been achieved.
 - d. Water resistant.
 - e. Mold and mildew resistant.
3. Two-Part Tape Sealing System: Comply with UL 181A; imprinted by manufacturer with coding "181A-M," manufacturer's name, and a date code.
 - a. Tape: Woven glass fiber impregnated with mineral gypsum.
 - b. Minimum Tape Width: **3 inches (76 mm)**.
 - c. Sealant: Modified styrene acrylic.
 - d. Water resistant.
 - e. Mold and mildew resistant.
 - f. Sealant shall have a VOC content of 420 g/L or less.
 - g. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - h. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - i. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

- j. Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- k. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

E. Fabrication:

1. Comply with: **[SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 3, "Specifications and Closure," and Ch. 4, "Fittings and Connections"]****[NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section II, "Fabrication of Straight Duct Modules," Section III, "Fabrication of Fittings from Modules or Flat Board," and Section IV, "Closure"]** for the following:
 - a. Joints, seams, transitions, elbows, and branch connections.
 - b. Reinforcements, including channel and tie rod reinforcement materials, spacing, and fabrications.
2. Fabricate 90-degree mitered elbows to include turning vanes.

- F. Reinforcements: Comply with requirements in **[SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 5, "Reinforcement"]****[NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section V, "Reinforcement"]** for channel- and tie-rod reinforcement materials, spacing, and fabrication.

2.3 PHENOLIC-FOAM DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following]****[provide products by one of the following]****[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[AQC Industries, LLC]**
2. **[Kingspan Insulation LLC]**
3. **[PTM Manufacturing, LLC]**
4. **[Thermaxduct]**
5. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[AQC Industries, LLC]**
2. **[Kingspan Insulation LLC]**
3. **[PTM Manufacturing, LLC]**
4. **[Thermaxduct]**
5. **<Insert manufacturer's name>**

- C. Duct Panel: CFC-free phenolic-foam bonded on both sides with factory-applied, **0.001-inch- (0.025-mm-)** thick, aluminum foil reinforced with fiberglass scrim.

1. Temperature Limits:

- a. Maximum 176 deg F (80 deg C).
 - b. Minimum: Minus 4 deg F (Minus 20 deg C).
 2. Maximum Thermal Conductivity: [0.15 Btu x in./h x sq. ft. x deg F (0.021 W/m x K)]<Insert conductivity> at 75 deg F (24 deg C) mean temperature.
 3. Permeability: 0.0002 perm (0.0115 ng/Pa x s x sq. m) maximum when tested according to ASTM E96/E96M, Procedure A.
 4. Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL, and registered by the EPA for use in HVAC systems.
 5. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C423, Mounting A.
 6. Fire/Smoke Resistance: Duct material shall comply with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E84.
 7. Required Markings: UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for closure materials.
- D. Closure Materials:
1. V-Groove Adhesive: Silicone.
 - a. Sealant shall have a VOC content of 420 g/L or less.
 - b. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - c. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - d. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - e. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - f. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
 2. Pressure-Sensitive Tape: Comply with UL 181A; imprinted by manufacturer with coding "181A-P," manufacturer's name, and a date code.
 - a. Tape: Aluminum foil tape imprinted with listing information.
 - b. Minimum Tape Width: 3 inches (76 mm).
 - c. Water resistant.
 - d. Mold and mildew resistant.
 3. Polymeric Sealing System:
 - a. Structural Membrane: Woven glass fiber.
 - b. Minimum Tape Width: 3 inches (76 mm).
 - c. Sealant: Water based.
 - d. Color: White.
 - e. Water resistant.
 - f. Mold and mildew resistant.

- g. Sealant shall have a VOC content of 420 g/L or less.
- h. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- i. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- j. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
- k. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- l. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

E. Fabrication:

- 1. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according manufacturer's written instructions.
- 2. Fabricate 90-degree mitered elbows to include turning vanes.

2.4 THERMOSET FRP DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- 1. **[Monoxivent Co.]**
- 2. **[Perry Fiberglass Products, Inc.]**
- 3. **[Viron International]**
- 4. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1. **[Monoxivent Co.]**
- 2. **[Perry Fiberglass Products, Inc.]**
- 3. **[Viron International]**
- 4. **<Insert manufacturer's name>**

C. Duct and Fittings:

- 1. Thermoset FRP Resin: Comply with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E84.
- 2. Inner Liner: FSK liner rated by an NRTL to comply with UL 181, Class 1.
- 3. Round Duct: ASTM D2996, Type I, Grade 2, Class E, filament-wound duct, minimum **[0.125-inch (3.2-mm)]<Insert dimension>** wall thickness, with tapered bell-and-spigot ends for adhesive joints or with plain ends with couplings.
- 4. Round Fittings: Compression or spray-up/contact, molded of same material, pressure class, and

- joining method as duct.
5. Rectangular Fittings: Minimum **[0.125-inch- (3.2-mm-)]<Insert dimension>** thick, flat sheet with fiberglass roving and resin-reinforced joints and seams.
 6. Double-Wall Insulated Duct: Inner and outer duct complying with requirements in "Round Duct" Subparagraph. Polyurethane foam or isocyanurate insulation with maximum thermal conductivity of **[0.14 Btu x in./h x sq. ft. x deg F (0.020 W/m x K)]<Insert conductivity>** at **75 deg F (24 deg C)** mean temperature.
- D. Joining Materials: Roving and polyester resin.
1. Fiberglass adhesive shall have a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).
 2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- E. Fabrication:
1. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoset FRP Duct Construction Manual," Ch. 7, "Requirements."
 2. Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for **12 inches (300 mm)** and smaller and a minimum of five segments for **14 inches (350 mm)** and larger.
- F. Drains: Formed drain pockets with a minimum of **NPS 1 (DN 25)** threaded pipe connections.

2.5 PVC DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[General Plastics, Inc]**
 2. **[GPK Products, Inc.]**
 3. **[Harrison Machine & Plastic Corporation]**
 4. **[Harvel Plastics, Inc.]**
 5. **[Kroy Industries, Inc.]**
 6. **[Spears Manufacturing Company]**
 7. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[General Plastics, Inc]**
 2. **[GPK Products, Inc.]**
 3. **[Harrison Machine & Plastic Corporation]**
 4. **[Harvel Plastics, Inc.]**
 5. **[Kroy Industries, Inc.]**
 6. **[Spears Manufacturing Company]**
 7. **<Insert manufacturer's name>**
- C. Duct and Fittings:
1. Material: Rigid, virgin PVC compound complying with ASTM D1784 Cell Classification 12454-B.
 2. Flammability: Maximum flame-spread index of not more than 25 without evidence of continued progressive combustion.
 3. External Loading Properties: ASTM D2412.
 4. Minimum Round Duct Wall Thickness: **[0.187 inch (4.75 mm) for up to 18-inch (450-mm)][0.219 inch (5.56 mm) for up to 20-inch (508-mm)][0.25 inch (6.35 mm) for up to 24-inch (610-mm)]<Insert dimensions>** duct.
 5. Round Fittings: Socket end molded of same material, pressure class, and joining method as duct.
 6. Rectangular Fittings: Minimum **[0.125-inch- (3.2-mm-)]<Insert dimension>** thick, flat sheet with heat-formed corners and continuous welded butt joints.
- D. Joining Materials: PVC solvent cement complying with ASTM D2564.
1. Adhesive primer shall have a VOC content of 550 g/L or less.
 2. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 3. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 5. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit or 33 mcg/cu. m and that of acetaldehyde shall not exceed 9 mcg/cu. m.
 6. Solvent cement shall have a VOC content of 510 g/L or less.
 7. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 8. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 9. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 10. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical

- Emissions from Indoor Sources Using Environmental Chambers."
11. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

E. Fabrication:

1. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."
2. Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for **12 inches (300 mm)** and smaller and a minimum of five segments for **14 inches (350 mm)** and larger.

F. Drains: PVC drain pockets with a minimum of **NPS 1 (DN 25)** threaded PVC pipe connections.

2.6 CPVC DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Harrison Machine & Plastic Corporation]**
2. **[Harvel Plastics, Inc]**
3. **[Spears Manufacturing Company]**
4. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Harrison Machine & Plastic Corporation]**
2. **[Harvel Plastics, Inc]**
3. **[Spears Manufacturing Company]**
4. **<Insert manufacturer's name>**

C. Duct and Fittings:

1. Material: Rigid, virgin CPVC compound complying with ASTM D1784 Cell Classification 23447.
2. Flammability: Maximum flame-spread index of not more than 25 without evidence of continued progressive combustion and a smoke-developed index of not more than 50.
3. Maximum Service Temperature: **200 deg F (93 deg C)**.
4. External Loading Properties: ASTM D2412.
5. Round Fittings: Socket end molded of same material, pressure class, and joining method as duct.
6. Rectangular Fittings: Minimum **[0.125-inch- (3.2-mm-)]<Insert dimension>** thick, flat sheet with heat-formed corners and continuous welded butt joints.

D. Joining Materials: CPVC solvent cement complying with ASTM D2564.

1. Adhesive primer shall have a VOC content of 550 g/L or less.
2. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
3. Adhesive primer shall comply with the testing and product requirements of the California

- Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
4. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 5. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit or 33 mcg/cu. m and that of acetaldehyde shall not exceed 9 mcg/cu. m.
 6. Solvent cement shall have a VOC content of 490 g/L or less.
 7. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 8. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 9. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 10. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 11. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

E. Fabrication:

1. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."
2. Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for **12 inches (300 mm)** and smaller and a minimum of five segments for **14 inches (350 mm)** and larger.

F. Drains: CPVC drain pockets with a minimum of **NPS 1 (DN 25)** threaded CPVC pipe connections.

2.7 HDPE DUCT AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[AQC Industries, LLC]**
2. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[AQC Industries, LLC]**
 2. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain HDPE duct system components from single manufacturer.
- D. Description: Complete HDPE underground duct system consisting of factory-manufactured components to suit duct layout configuration including straight round duct, elbows, **[plenums,][run-outs,][diffuser boots,]** fitting clamps, gaskets, bolts, sealant, and other components required for a complete underground ductwork system.
- E. Duct and Fittings:
1. Material:
 - a. Closed-cell recyclable HDPE plastic.
 - b. Does not emit VOCs.
 - c. Leakage: Air leakage testable, exceeding SMACNA Leakage Class 3 requirements at system design static pressure.
 - d. Thermal Distribution Efficiency: Inherent R-10 equivalent thermal insulation efficiency without using a separate insulation layer, tested in accordance with NSF P374 protocol and verified by an NSF thermal testing report.
 - e. Resistant to mildew, mold, and rust.
 - f. Remains stable, without cracking, when subjected to underground stresses and strains.
 - g. Rated for maximum **10-inch wg (2.5-kPa)** positive pressure and maximum rated **2-inch wg (0.5-kPa)** negative pressure.
 - h. Surface-Burning Characteristics: Flame-spread index of 200 or less when tested in accordance with ASTM E84.
 - i. Flood Plain Elevation: Tested to withstand **8-foot (2.4-m)** water column pressure for seven days with no leakage.
- F. Joining Materials:
1. **Flanged Ductwork: Join with stainless steel bolts and water- and UV-resistant copolymer adhesive caulking sealant.**
 2. **Unflanged Ductwork:**
 - a. **Clamps: Polyethylene clamps with stainless steel plates and stainless steel screws.**
 - b. **Gaskets: Butyl rubber gaskets, minimum 0.25 inch (6 mm) thick.**
- 2.8 HANGERS AND SUPPORTS
- A. Hanger Rods for Noncorrosive Environments: Zinc-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," **Table 5-1 (Table 5-1M)**, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables: **[ASTM A603, galvanized][ASTM A492, stainless]**-steel cables with end connections made of **[zinc-plated][stainless]**-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct

materials.

- F. Trapeze and Riser Supports: Steel shapes complying with ASTM A36/A36M.

2.9 SEISMIC-RESTRAINT DEVICES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Atkore Unistrut]**
2. **[CADDY; brand of nVent Electrical plc]**
3. **[Cooper B-line; brand of Eaton, Electrical Sector]**
4. **[Ductmate Industries, Inc; a DMI company]**
5. **[Hilti, Inc.]**
6. **[Kinetics Noise Control, Inc]**
7. **[Mason Industries, Inc.]**
8. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Atkore Unistrut]**
2. **[CADDY; brand of nVent Electrical plc]**
3. **[Cooper B-line; brand of Eaton, Electrical Sector]**
4. **[Ductmate Industries, Inc; a DMI company]**
5. **[Hilti, Inc.]**
6. **[Kinetics Noise Control, Inc]**
7. **[Mason Industries, Inc.]**
8. **<Insert manufacturer's name>**

- C. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by **[an evaluation service member of ICC-ES][the Office of Statewide Health Planning and Development for the State of California][an agency acceptable to authorities having jurisdiction]**.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least **[four]<Insert number>** times the maximum seismic forces to which they will be subjected.

- D. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

- E. Restraint Cables: **[ASTM A603, galvanized][ASTM A492, stainless]**-steel cables with end connections made of **[zinc plated][stainless-]**steel assemblies with brackets, swivel, and bolts designed for restraining cable service; with an automatic-locking and clamping device or double-cable clips.

- F. Hanger Rod Stiffener: **[Steel tube or steel slotted-support-system sleeve with internally bolted connections][Reinforcing steel angle clamped]** to hanger rod.

- G. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install duct sections in maximum practical lengths with fewest possible joints.
- C. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- D. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- E. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- F. Install ducts with a minimum clearance of **1 inch (25 mm)**, plus allowance for insulation thickness.
- G. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- H. Where ducts pass through non-fire-rated interior partitions and exterior walls, and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges. Overlap openings on four sides by at least **1-1/2 inches (38 mm)**.
- I. Install fire[, **combination fire/smoke,**] and smoke dampers where indicated on Drawings and as required by code and by authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the fire damper UL listing.
- J. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
- K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. [**Comply with SMACNA's "IAQ Guidelines for Occupied Buildings under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."**]
- L. Elbows: Use long-radius elbows wherever they fit.
 - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for **12 inches (300 mm)** and smaller and a minimum of five segments for **14 inches (350 mm)** and larger.
- M. Branch Connections: Use lateral or conical branch connections.
- N. Install fibrous-glass ducts and fittings to comply with [**NAIMA AH116, "Fibrous Glass Duct Construction Standards."**] [**SMACNA's "Fibrous Glass Duct Construction Standards."**]
- O. Install phenolic-foam ducts and fittings to comply with SMACNA's "Phenolic Duct Construction Standards."

- P. Install thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual."
- Q. Install PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual."
- R. Install CPVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual."
- S. Install HDPE ducts, fittings, and components to comply with manufacturer's written installation instructions. Installer to complete manufacturer's installation training prior to installation.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Install hangers and supports for fibrous-glass ducts and fittings to comply with **[SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 6, "Hangers and Supports."][NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section VI, "Hangers and Supports."]**
- B. Install hangers and supports for phenolic-foam ducts and fittings to comply with SMACNA's "Phenolic Duct Construction Standards" Ch. 6, "Hangers and Supports" and with manufacturer's written instructions.
- C. Install hangers and supports for thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual," Ch. 7, "Requirements."
- D. Install hangers and supports for PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."
- E. Install hangers and supports for CPVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."
- F. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than **4 inches (100 mm)** thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than **4 inches (100 mm)** thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- G. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 SEISMIC-RESTRAINT-DEVICE INSTALLATION

- A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. See Section 230548 "Vibration and Seismic Controls for HVAC." Comply with **[SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."][ASCE/SEI 7.]**

1. Space lateral supports a maximum of **[40 feet (12 m)]<Insert dimension>** o.c., and longitudinal supports a maximum of **[80 feet (24 m)]<Insert dimension>** o.c.
2. Brace a change of direction longer than **12 feet (3.7 m)**.
- B. Select sizes of components so strength will be adequate to carry calculated static and seismic loads within restraint device capacity.
- C. Install restraint cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install restraint cables where ducts are suspended with vibration isolators.
- E. Install seismic-restraint devices using methods approved by **[an evaluation service member of the ICC Evaluation Service][the Office of Statewide Health Planning and Development for the State of California][an agency acceptable to authorities having jurisdiction]**.
- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure to flanges of beams, to upper truss chords of bar joists, or to concrete members.
- G. Drilling for Post-Installed Concrete Anchors:
 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and water and gas lines.
 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 6. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.4 PAINTING

- A. Paint interior of **[thermoset FRP][PVC][and][CPVC]** ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, acrylic or latex paint that is chemically compatible with duct material. Confirm compatibility information with paint manufacturer. Oil-based paint is not recommended. Paint materials and application requirements are specified in Section 099123 "Interior Painting."

3.5 STARTUP SERVICE

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and

inspections.

- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
 - 1. Leakage Tests:
 - a. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - b. Where static pressure and leakage values shown below differ from those in the SMACNA manual, the more stringent values shall apply.
 - c. Test the following systems:
 - 1) Ducts with a Pressure Class Higher Than **3-Inch wg (750 Pa)**: Test representative duct sections[, **selected by Architect from sections installed,**] totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - 2) Supply Ducts with a Pressure Class of **[2-Inch wg (500 Pa)][3-Inch wg (750 Pa)][4-Inch wg (1000 Pa)]<Insert value>** or Higher: Test representative duct sections[, **selected by Architect from sections installed,**] totaling no less than **[50][100]<Insert number>** percent of total installed duct area for each designated pressure class.
 - 3) Return Ducts with a Pressure Class of **[2-Inch wg (500 Pa)][3-Inch wg (750 Pa)][4-Inch wg (1000 Pa)]<Insert value>** or Higher: Test representative duct sections[, **selected by Architect from sections installed,**] totaling no less than **[50][100]<Insert number>** percent of total installed duct area for each designated pressure class.
 - 4) Exhaust Ducts with a Pressure Class of **[2-Inch wg (500 Pa)][3-Inch wg (750 Pa)][4-Inch wg (1000 Pa)]<Insert value>** or Higher: Test representative duct sections[, **selected by Architect from sections installed,**] totaling no less than **[50][100]<Insert number>** percent of total installed duct area for each designated pressure class.
 - 5) Outdoor Air Ducts with a Pressure Class of **[2-Inch wg (500 Pa)][3-Inch wg (750 Pa)][4-Inch wg (1000 Pa)]<Insert value>** or Higher: Test representative duct sections[, **selected by Architect from sections installed,**] totaling no less than **[50][100]<Insert number>** percent of total installed duct area for each designated pressure class.
 - d. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - e. Test for leaks before applying external insulation.
 - f. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - g. Give **[seven]<Insert number>** days' advance notice for testing.
 - 2. Duct System Cleanliness Tests:
 - a. Test protocols shall be performed according to NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems," "Section 5 - Cleanliness Verification and Documentation."
 - b. Visually inspect duct system to ensure that no visible contaminants are present.
 - c. Test sections of fibrous-glass duct system chosen randomly by Owner for cleanliness according to "Method 2 Protocol."

- d. Test sections of Phenolic-foam, Thermoset FRP, PVC, and CPVC duct systems chosen randomly by Owner, for cleanliness according to "Method 3 - NADCA Vacuum Test."
 - 1) Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
3. Duct system will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

3.7 DUCT CLEANING

- A. Clean duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch duct as recommended by duct manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. Particulate Collection and Odor Control:
 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron (or larger) particles.
 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- D. Clean the following components by removing surface contaminants and deposits:
 1. Air outlets and inlets (registers, grilles, and diffusers).
 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 4. Coils and related components.
 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 6. Supply-air ducts, dampers, actuators, and turning vanes.
 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:
 1. All duct cleaning shall be performed according to NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of ducts or duct accessories.
 4. Clean fibrous-glass duct with HEPA vacuuming equipment; do not permit duct to get wet. Replace fibrous-glass duct that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for washdown procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removing surface deposits and debris.

3.8 DUCT SCHEDULE

A. Indoor Ducts and Fittings:

1. Fibrous-Glass Rectangular Ducts and Fittings:
 - a. Minimum Flexural Rigidity: EI-[475][800][1400].
 - b. Minimum Board Thickness: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (51 mm)].
2. Phenolic-Foam Rectangular Ducts and Fittings:
 - a. Minimum Panel Thickness: [7/8 inch (22 mm)][1-3/32 inches (30 mm)].
 - b. Aluminum Cladding: Minimum 0.025 inch (0.635 mm) thick.
 - c. Joints: Secure joints with adhesive or clips according to duct manufacturer's written instructions, then tape joints with aluminum vapor tape.
 - d. Sealing: All joints shall be sealed with a generous and continuous bead of silicone sealant and pressed into corners using a smooth radius tool.

B. Outdoor Ducts and Fittings:

1. Provide suitable external surface protection as recommended by manufacturer.
2. Phenolic-Foam Rectangular Ducts and Fittings:
 - a. Minimum Panel Thickness: [7/8 inch (22 mm)][1-3/32 inches (28 mm)].
 - b. Aluminum Cladding: Minimum 0.032 inch (0.813 mm) thick.
 - c. Joints: Secure joints with adhesive or clips according to duct manufacturer's written instructions, then tape joints with aluminum vapor tape.
 - d. Sealing: All joints shall be sealed with a generous and continuous bead of silicone sealant and pressed into corners using a smooth radius tool.
3. Thermoset FRP Round Ducts and Fittings:
 - a. Double-Wall Insulated Ducts: Minimum [5/8-inch (15.9-mm)][7/8-inch (22.2-mm)][1-inch (25.4-mm)] insulation thickness with [k-factor of 14 (2.02-W/mK)]<Insert value> insulation thickness.

C. Underground Ducts:

1. Provide suitable external surface protection as recommended by manufacturer.
2. Thermoset FRP Round Ducts and Fittings:
 - a. Double wall.
 - b. Insulation Thickness: [1 inch (25 mm)]<Insert dimension>.
 - c. Drain: Minimum NPS 1 (DN 25) PVC pipe with P-trap to air-gap drain.
3. PVC Round Ducts and Fittings:



- a. Drain: Minimum **NPS 1 (DN 25)** PVC pipe with P-trap to air-gap drain.
- 4. CPVC Round Ducts and Fittings:
 - a. Drain: Minimum **NPS 1 (DN 25)** CPVC pipe with P-trap to air-gap drain.
- 5. HDPE Round Ducts and Fittings: Drain as recommended by manufacturer.
- D. Fume Exhaust:
 - 1. Thermoset FRP ducts and fittings.
 - 2. Install exhaust ducts without dips and traps that may hold condensate or other liquid, and sloped a minimum of 2 percent to drain. Where indicated on Drawings, install trapped drain piping.
 - 3. Connect duct to fume hood or other equipment where indicated on Drawings.

END OF SECTION 23 31 16 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 31 16 00	23 31 00 00	Shop-Fabricated HVAC Casings
23 31 16 13	23 31 13 00	Metal Ducts
23 31 16 13	23 31 16 00	Nonmetal Ducts
23 31 16 13	23 31 00 00	Shop-Fabricated HVAC Casings
23 31 16 16	23 31 13 00	Metal Ducts
23 31 16 16	23 31 16 00	Nonmetal Ducts
23 31 16 16	23 31 00 00	Shop-Fabricated HVAC Casings



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 31 16 23 - FABRIC AIR-DISTRIBUTION DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fabric air-distribution duct and devices.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
- B. Shop Drawings: For fabric air-distribution devices.
 - 1. Include plans, elevations, sections, and suspension and attachment details.
- C. Samples for Initial Selection: Fabric samples for air-distribution devices with factory-applied color finishes.
- D. Samples for Verification: Fabric samples for air-distribution devices, in manufacturer's standard sizes to verify color selected.
- E. Diffuser Schedule: Use same designations indicated on Drawings. Indicate room location, quantity, model number, size, and accessories furnished.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.
- B. Source quality control reports.

PART 2 - PRODUCTS

2.1 FABRIC AIR-DISTRIBUTION DUCT AND DEVICES

- A. Fabric Air-Distribution Duct and Devices:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. [Air Distribution Concepts]
- b. [Airmax International]
- c. [Berner International]
- d. [DuctSox Corp.]
- e. [Durkee America Inc.]
- f. [Fabric Duct Systems]
- g. [FabricAir Inc.]
- h. [KE Fibertec NA, Inc]
- i. [Prihoda North America]
- j. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Air Distribution Concepts]
- b. [Airmax International]
- c. [Berner International]
- d. [DuctSox Corp.]
- e. [Durkee America Inc.]
- f. [Fabric Duct Systems]
- g. [FabricAir Inc.]
- h. [KE Fibertec NA, Inc]
- i. [Prihoda North America]
- j. <Insert manufacturer's name>

B. Source Limitations: Obtain fabric air duct and distribution devices from a single manufacturer.

C. Performance Requirements:

- 1. Continuous tubular diffuser materials are to be listed and labeled as complying with [UL 2518][UL 723][NFPA 90A][NFPA 90B][NFPA 701][ASTM E84].
- 2. Air permeability of fabric is to comply with ASTM D737.

D. Description:

- 1. Fabric: [Woven polyethylene][Woven, coated polyethylene][Polyester][Anti-microbial-coated polyester][Vinyl-coated polyester][Anti-static polyester][High-temperature fiberglass][Permeable polyester]<Insert material>.
- 2. Shape: [Round][Oval][Half round]<Insert shape>.
- 3. Air-Outlet Configuration:
 - a. Permeable fabric.
 - b. Circumferential hole pattern with diffusion-hole diameter of <Insert inches (mm)>, spaced <Insert inches (mm)> o.c. circumferentially, and <Insert inches (mm)> along the length of the diffusion device.
 - c. Lengthwise mesh.
 - d. Lengthwise hole pattern; with diffusion-hole diameter of <Insert inches (mm)>.
 - e. Periodic nozzles.
 - f. Linear vents.

- 1) Color: <Insert color>.

E. Duct Connection Type: Round [worm-gear band][radial securing clips][zipper].



F. Accessories:

1. Quick-connect joint.
2. Snap hooks.
3. Cleanout zipper.
4. Condensate drain.
5. Fabric damper.
6. End cap.
7. Draw cords.
8. Removable support hoops.
9. Elbows.

PART 3 - EXECUTION

3.1 INSTALLATION OF FABRIC AIR-DISTRIBUTION DUCT AND DEVICES

- A. Drawings indicate general arrangement of ducts, fittings, and accessories. Air-outlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated. Where architectural features or other items conflict with installation, notify Architect to determine final location.

END OF SECTION 23 31 16 23



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 31 16 23	23 31 16 00	Nonmetal Ducts
23 31 16 23	23 31 00 00	Shop-Fabricated HVAC Casings



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 33 00 00 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Ceiling radiation dampers.
7. Smoke dampers.
8. Combination fire and smoke dampers.
9. Corridor dampers.
10. Flange connectors.
11. Duct-mounted duct silencers.
12. Turning vanes.
13. Remote damper operators.
14. Duct-mounted access doors.
15. Duct access panel assemblies.
16. Flexible connectors.
17. Duct security bars.
18. Duct accessory hardware.
19. Flexible ducts, noninsulated.
20. Flexible ducts, insulated.
21. Flexible duct connectors.

B. Related Requirements:

1. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
2. Section 284600 "Fire Detection and Alarm" for duct-mounted heat, smoke, and carbon-monoxide detectors.
3. Section 284614 "Single- and Multiple- Station Alarms" for standalone duct-mounted heat, smoke, and carbon-monoxide detectors/alarms.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, and dimensions of individual components.
2. For dampers, include housings, linkages, and operators.
3. For damper operators, include electrical or pneumatic pressure rating and damper size rating.
4. For duct-mounted duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

B. Shop Drawings: For air duct accessories.

1. Plans showing locations, elevations, sections, and attachment details.
2. Duct accessories' fabrication and installation in ducts and other construction. Include dimensions,

weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

- a. Special fittings.
- b. Manual volume damper installations.
- c. Control-damper installations.
- d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
- e. Duct security bars.
- f. Diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

1. Product Data: Showing compliance with ASHRAE 62.1.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, or BIM model, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.
- B. Source quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fusible Links: Furnish quantity equal to [10]<Insert number> percent of amount installed.

PART 2 - PRODUCTS

2.1 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [American Warming and Ventilating (AWV); Mestek, Inc.]
 2. [Cesco Products; MESTEK, Inc.]
 3. [Greenheck Fan Corporation]
 4. [Lloyd Industries, Inc.]
 5. [Nailor Industries Inc]
 6. [Pottorff]

7. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 8. [Safe Air - Dowco]
 9. [United Enertech Corp.]
 10. [Vent Products Co., Inc]
 11. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [American Warming and Ventilating (AWV); Mestek, Inc.]
 2. [Cesco Products; MESTEK, Inc.]
 3. [Greenheck Fan Corporation]
 4. [Lloyd Industries, Inc.]
 5. [Nailor Industries Inc]
 6. [Pottorff]
 7. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 8. [Safe Air - Dowco]
 9. [United Enertech Corp.]
 10. [Vent Products Co., Inc]
 11. <Insert manufacturer's name>
- C. Description: Gravity balanced [with adjustable counterweight][or][with spring][with motorized actuator].
- D. Performance:
1. Maximum Air Velocity: [1000 fpm (5.1 m/s)][1250 fpm (6.4 m/s)][2000 fpm (10 m/s)][3000 fpm (15 m/s)]<Insert value>.
 2. Maximum System Pressure: [1 inch wg (0.25 kPa)][2 inches wg (0.5 kPa)][3 inches wg (0.8 kPa)][6 inches wg (1.5 kPa)]<Insert value>.
 3. AMCA Certification: Test and rate in accordance with AMCA 511.
 4. Leakage:
 - a. Class IA: Leakage is not to exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1 inch wg (250 Pa) differential static pressure.
 - b. Class I: Leakage is not to exceed 4 cfm/sq. ft. (20 L/s per sq. m) against 1 inch wg (250 Pa) differential static pressure.
 - c. Class II: Leakage is not to exceed 10 cfm/sq. ft. (51 L/s per sq. m) against 1 inch wg (250 Pa) differential static pressure.
 - d. Class III: Leakage is not to exceed 40 cfm/sq. ft. (203 L/s per sq. m) against 1 inch wg (250 Pa) differential static pressure.
- E. Construction:
1. Frame:
 - a. Hat shaped.
 - b. [16-gauge- (1.6-mm-) thick, galvanized sheet steel][10-gauge- (3.5-mm-) thick, galvanized sheet steel][0.093-inch- (2.4-mm-) thick extruded aluminum][18-gauge- (1.3-mm-) thick stainless steel]<Insert value and frame material type>, with welded or mechanically attached corners[and mounting flange].
 2. Blades:
 - a. Multiple single-piece blades.
 - b. [Center][Off-center][End] pivoted, maximum 6-inch (150-mm) width, [16-gauge- (1.6-



mm-) thick, galvanized sheet steel][0.050-inch- (1.2-mm-) thick aluminum sheet][26-gauge (0.48-mm) Type 304 stainless steel][noncombustible, tear-resistant, neoprene-coated fiberglass]<Insert value and blade material type> with sealed edges.

3. Blade Action: Parallel.
- F. Blade Seals: **[Felt][Vinyl foam][Extruded vinyl, mechanically locked][Neoprene, mechanically locked]**.
- G. Blade Axles:
 1. Material: **[Nonferrous metal][Galvanized steel][Plated steel][Stainless steel][Nonmetallic][Aluminum]**.
 2. Diameter: **[0.20 inch (5 mm)][0.50 inch (13 mm)]<Insert dimension>**.
- H. Tie Bars and Brackets: **[Aluminum][Galvanized steel]**.
- I. Counterbalance: **[Adjustable counterweight][Adjustable-tension return spring][Motorized actuator]**.
- J. Bearings: **[Steel ball][Brass sleeve][or][synthetic pivot bushings]**.
- K. Damper Actuator - Electric:
 1. Electric - **[120 V ac][24 V ac]**.
 2. UL 60730-2-14 and UL 2043 plenum rated.
 3. Actuator Type: **[Two position][Fully modulating][with fail-safe spring return]**.
 - a. Sufficient motor torque **[and spring torque]** to drive damper fully closed with adequate force to achieve required damper seal.
 - b. Minimum 90-degree drive rotation.
 4. Clockwise or counterclockwise drive rotation as required for application.
 5. Environmental Operating Range:
 - a. Temperature: **Minus 40 to plus 130 deg F (Minus 40 to plus 55 deg C)**.
 - b. Humidity: 5 to 95 percent relative humidity noncondensing.
 6. Environmental Enclosure: NEMA 2.
 7. Actuator to be factory mounted and provided with a single-point wiring connection.
- L. Damper Actuator - Pneumatic:
 1. Operated by **0 to 20 psig (0 to 138 kPa)** pneumatic signal.
 2. Actuator Type: **[Two position with][Fully modulating with positioner and]** fail-safe spring return.
 - a. Sufficient power and spring force to drive damper fully closed with adequate force to achieve required damper seal.
 - b. Maximum 15-second full-stroke closure.
 3. Actuator to be factory mounted.
- M. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: **[115 V, single phase, 60 Hz][24 V, 60 Hz]<Insert values>**.

N. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Chain pulls.
4. 90-degree stops.
5. Screen:
 - a. Mounting:
 - 1) **[Front][Rear]** mounted in sleeve.
 - a) Sleeve Thickness: **20 gauge (1.0 mm)** minimum.
 - b) Sleeve Length: **6 inches (150 mm)** minimum.
 - b. Material: **[Galvanized steel][Aluminum]**.
 - c. Type: **[Bird][Insect]**.

2.2 BAROMETRIC RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
2. **[Cesco Products; MESTEK, Inc.]**
3. **[Greenheck Fan Corporation]**
4. **[Lloyd Industries, Inc.]**
5. **[Nailor Industries Inc]**
6. **[Pottorff]**
7. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
8. **[Safe Air - Dowco]**
9. **[United Enertech Corp.]**
10. **[Vent Products Co., Inc]**
11. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
2. **[Cesco Products; MESTEK, Inc.]**
3. **[Greenheck Fan Corporation]**
4. **[Lloyd Industries, Inc.]**
5. **[Nailor Industries Inc]**
6. **[Pottorff]**
7. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
8. **[Safe Air - Dowco]**
9. **[United Enertech Corp.]**
10. **[Vent Products Co., Inc]**
11. **<Insert manufacturer's name>**

C. General Requirements:

1. Suitable for horizontal or vertical mounting.
2. Maximum Air Velocity: [1000 fpm (5.1 m/s)][1250 fpm (6.4 m/s)][2000 fpm (10 m/s)][2500 fpm (13 m/s)]<Insert value>.
3. Maximum System Pressure: [2 inches wg (0.5 kPa)][3 inches wg (0.8 kPa)][6 inches wg (1.5 kPa)][10 inches wg (2.5 kPa)]<Insert value>.

D. Construction:

1. Frame: Hat shaped, [16-gauge- (1.6-mm-) thick, galvanized sheet steel][13-gauge- (2.4-mm-) thick, galvanized sheet steel][0.093-inch- (2.4-mm-) thick extruded aluminum][18-gauge- (1.3-mm-) thick stainless steel][18-gauge- (1.3-mm-) thick stainless steel]<Insert value and frame material type>, with welded corners or mechanically attached[, with mounting flange].
2. Blades:
 - a. Multiple, [16-gauge- (1.6-mm-) thick, galvanized sheet steel][0.050-inch- (1.2-mm-) thick aluminum sheet][26-gauge (0.48-mm) Type 304 stainless steel].
 - b. Maximum Width: 6 inches (150 mm).
 - c. Action: Parallel.
 - d. Balance: Gravity.
 - e. [Eccentrically][Off-center][End] pivoted.
 - f. Seals: [Vinyl][Neoprene].
 - g. Axles: [Galvanized steel][Nonferrous metal][Plated steel][Stainless steel][Nonmetallic].
3. Tie Bars and Brackets:
 - a. Material: [Aluminum][Galvanized steel].
 - b. Rattle free with 90-degree stop.
4. Bearings: [Synthetic][Stainless steel][Ball bearing].

E. Pressure Adjustment: Return spring or counter weight with adjustable tension.

F. Accessories:

1. Flange on intake.
2. [Bird][Insect] screen on [intake][discharge].
3. Adjustment device to permit setting for varying differential static pressures.
4. <Insert accessories>.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Air Balance; MESTEK, Inc.]
 - b. [Aire Technologies, Inc.; DMI Companies]
 - c. [American Warming and Ventilating (AWV); Mestek, Inc.]

- d. **[Arrow United Industries; Mestek, Inc.]**
 - e. **[Cesco Products; MESTEK, Inc.]**
 - f. **[Greenheck Fan Corporation]**
 - g. **[Lloyd Industries, Inc.]**
 - h. **[McGill AirFlow LLC]**
 - i. **[Nailor Industries Inc]**
 - j. **[NCA Manufacturing, Inc.; Metal Industries, Inc.]**
 - k. **[Pottorff]**
 - l. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - m. **[Safe Air - Dowco]**
 - n. **[United Enertech Corp.]**
 - o. **[Vent Products Co., Inc]**
 - p. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Balance; MESTEK, Inc.]**
 - b. **[Aire Technologies, Inc.; DMI Companies]**
 - c. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - d. **[Arrow United Industries; Mestek, Inc.]**
 - e. **[Cesco Products; MESTEK, Inc.]**
 - f. **[Greenheck Fan Corporation]**
 - g. **[Lloyd Industries, Inc.]**
 - h. **[McGill AirFlow LLC]**
 - i. **[Nailor Industries Inc]**
 - j. **[NCA Manufacturing, Inc.; Metal Industries, Inc.]**
 - k. **[Pottorff]**
 - l. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - m. **[Safe Air - Dowco]**
 - n. **[United Enertech Corp.]**
 - o. **[Vent Products Co., Inc]**
 - p. **<Insert manufacturer's name>**
3. Performance:
 - a. Leakage Rating Class III: Leakage not exceeding **40 cfm/sq. ft. (203 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
4. Construction:
 - a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
5. Frames:
 - a. Hat-shaped, **[16-gauge- (1.6-mm-) thick, galvanized sheet steel][18-gauge- (1.3-mm-) thick stainless steel]**.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.



- c. Stiffen damper blades for stability.
 - d. **[Galvanized][Stainless]** steel; **16 gauge (1.6 mm)** thick.
7. Blade Axles: **[Galvanized steel][Stainless steel][Nonferrous metal]**.
8. Bearings: **[Oil-impregnated bronze][Molded synthetic][Oil-impregnated stainless steel sleeve][Stainless steel sleeve]**.
- a. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
9. Tie Bars and Brackets: Galvanized steel.
10. Locking device to hold damper blades in a fixed position without vibration.

B. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Cesco Products; MESTEK, Inc.]**
 - d. **[Linx Industries; a DMI company (formerly Lindab)]**
 - e. **[Nailor Industries Inc]**
 - f. **[Pottorff]**
 - g. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - h. **[Safe Air - Dowco]**
 - i. **[United Enertech Corp.]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - b. **[Arrow United Industries; Mestek, Inc.]**
 - c. **[Cesco Products; MESTEK, Inc.]**
 - d. **[Linx Industries; a DMI company (formerly Lindab)]**
 - e. **[Nailor Industries Inc]**
 - f. **[Pottorff]**
 - g. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - h. **[Safe Air - Dowco]**
 - i. **[United Enertech Corp.]**
 - j. **<Insert manufacturer's name>**
3. Performance:
- a. Leakage Rating Class III: Leakage not exceeding **40 cfm/sq. ft. (203 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
4. Construction:
- a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.

5. Frames:
 - a. Hat-shaped, **0.10-inch- (2.5-mm-)** thick, aluminum sheet channels.
 - b. Flanges for attaching to walls and flangeless frames for installing in ducts.
 6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Roll-Formed Aluminum Blades: **0.10-inch- (2.5-mm-)** thick aluminum sheet.
 - e. Extruded-Aluminum Blades: **0.050-inch- (1.2-mm-)** thick extruded aluminum.
 7. Blade Axles: **[Galvanized steel][Stainless steel][Nonferrous metal]**.
 8. Bearings: **[Oil-impregnated bronze][Molded synthetic][Stainless steel sleeve]**.
 - a. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
 9. Tie Bars and Brackets: Aluminum.
 10. Locking device to hold damper blades in a fixed position without vibration.
- C. Low-Leakage, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Air Balance; MESTEK, Inc.]**
 - b. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - c. **[Arrow United Industries; Mestek, Inc.]**
 - d. **[Cesco Products; MESTEK, Inc.]**
 - e. **[Greenheck Fan Corporation]**
 - f. **[Nailor Industries Inc]**
 - g. **[Pottorff]**
 - h. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - i. **[Safe Air - Dowco]**
 - j. **[Vent Products Co., Inc]**
 - k. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Air Balance; MESTEK, Inc.]**
 - b. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - c. **[Arrow United Industries; Mestek, Inc.]**
 - d. **[Cesco Products; MESTEK, Inc.]**
 - e. **[Greenheck Fan Corporation]**
 - f. **[Nailor Industries Inc]**
 - g. **[Pottorff]**
 - h. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - i. **[Safe Air - Dowco]**
 - j. **[Vent Products Co., Inc]**
 - k. **<Insert manufacturer's name>**

3. Performance:
 - a. AMCA Certification: Test and rate in accordance with AMCA 511.
 - b. Leakage:
 - 1) Class IA: Leakage is not to exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 - 2) Class I: Leakage is not to exceed **4 cfm/sq. ft. (20 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 - 3) Class II: Leakage is not to exceed **10 cfm/sq. ft. (51 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 4. Construction:
 - a. Linkage: Out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
 5. Frames:
 - a. Hat, U, or angle shaped.
 - b. Thickness: **[16-gauge (1.6-mm) galvanized sheet steel][18-gauge (1.3-mm) stainless steel]**.
 - c. Mitered and welded corners.
 - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
 6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. **[Galvanized][Stainless]**, roll-formed steel; **16 gauge (1.6 mm)** thick.
 7. Blade Edging Seals:
 - a. **[Closed-cell neoprene][PVC]**.
 - b. Inflatable seal blade edging or replaceable rubber seals.
 8. Blade Jamb Seals: **[Flexible metal compression type][Felt][Vinyl][Neoprene]**.
 9. Blade Axles: **[Galvanized steel][Stainless steel][Nonferrous metal]**.
 10. Bearings: **[Oil-impregnated bronze][Molded synthetic][Oil-impregnated stainless steel sleeve][Stainless steel sleeve]**.
 - a. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
 11. Tie Bars and Brackets: **[Galvanized steel][Aluminum]**.
 12. Locking device to hold damper blades in a fixed position without vibration.
- D. Low-Leakage, Aluminum, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [Air Balance; MESTEK, Inc.]
 - b. [American Warming and Ventilating (AWV); Mestek, Inc.]
 - c. [Arrow United Industries; Mestek, Inc.]
 - d. [Cesco Products; MESTEK, Inc.]
 - e. [Pottorff]
 - f. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - g. [Safe Air - Dowco]
 - h. [United Enertech Corp.]
 - i. [Vent Products Co., Inc]
 - j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Air Balance; MESTEK, Inc.]
 - b. [American Warming and Ventilating (AWV); Mestek, Inc.]
 - c. [Arrow United Industries; Mestek, Inc.]
 - d. [Cesco Products; MESTEK, Inc.]
 - e. [Pottorff]
 - f. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - g. [Safe Air - Dowco]
 - h. [United Enertech Corp.]
 - i. [Vent Products Co., Inc]
 - j. <Insert manufacturer's name>
3. Performance:
 - a. AMCA Certification: Test and rate in accordance with AMCA 511.
 - b. Leakage:
 - 1) Class IA: Leakage is not to exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 - 2) Class I: Leakage is not to exceed **4 cfm/sq. ft. (20 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 - 3) Class II: Leakage is not to exceed **10 cfm/sq. ft. (51 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
4. Construction:
 - a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
5. Frames:
 - a. Hat, U, or angle shaped.
 - b. Thickness: **0.08-inch (2.0-mm)** aluminum sheet channels.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Roll-Formed Aluminum Blades: **0.072-inch (1.8-mm-)** thick aluminum sheet.
 - d. Extruded-Aluminum Blades: **0.050-inch- (1.2-mm-)** thick extruded aluminum.

7. Blade Edging Seals: **[Closed-cell neoprene][PVC]**.
 - a. Inflatable seal blade edging or replaceable rubber seals.
8. Blade Jamb Seals: **[Flexible metal compression type][Felt][Vinyl][Neoprene]**.
9. Blade Axles: **[Galvanized steel][Stainless steel][Nonferrous metal]**.
10. Bearings: **[Oil-impregnated bronze][Molded synthetic][Oil-impregnated stainless steel sleeve][Stainless steel sleeve]**.
 - a. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.
11. Tie Bars and Brackets: **[Galvanized steel][Aluminum]**.
12. Locking device to hold damper blades in a fixed position without vibration.

E. Jackshaft:

1. Size: **[0.5-inch (13-mm)][1-inch (25-mm)]** diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle, made of **3/32-inch- (2.4-mm-)** thick zinc-plated steel, and a **3/4-inch (19-mm)** hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 CONTROL DAMPERS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[American Warming and Ventilating (AWV); Mestek, Inc.]**
2. **[Arrow United Industries; Mestek, Inc.]**
3. **[Carnes Company]**
4. **[Cesco Products; MESTEK, Inc.]**
5. **[Greenheck Fan Corporation]**
6. **[Lloyd Industries, Inc.]**
7. **[McGill AirFlow LLC]**
8. **[Metal Form Manufacturing LLC; United Enertech Corp.]**
9. **[Nailor Industries Inc]**
10. **[NCA Manufacturing, Inc.; Metal Industries, Inc.]**
11. **[Pottorff]**
12. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
13. **[Safe Air - Dowco]**
14. **[United Enertech Corp.]**
15. **[Vent Products Co., Inc]**
16. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [American Warming and Ventilating (AWV); Mestek, Inc.]
2. [Arrow United Industries; Mestek, Inc.]
3. [Carnes Company]
4. [Cesco Products; MESTEK, Inc.]
5. [Greenheck Fan Corporation]
6. [Lloyd Industries, Inc.]
7. [McGill AirFlow LLC]
8. [Metal Form Manufacturing LLC; United Enertech Corp.]
9. [Nailor Industries Inc]
10. [NCA Manufacturing, Inc.; Metal Industries, Inc.]
11. [Pottorff]
12. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
13. [Safe Air - Dowco]
14. [United Enertech Corp.]
15. [Vent Products Co., Inc]
16. <Insert manufacturer's name>

C. General Requirements:

1. Unless otherwise indicated, use parallel-blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
2. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.

D. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA 511.
2. Leakage:
 - a. Class IA: Leakage is not to exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 - b. Class I: Leakage is not to exceed **4 cfm/sq. ft. (20 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 - c. Class II: Leakage is not to exceed **10 cfm/sq. ft. (51 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 - d. Class III: Leakage is not to exceed **40 cfm/sq. ft. (203 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
3. Pressure Drop: **0.05 inch wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to **[3000 fpm (15 m/s)]<Insert velocity>**.
5. Temperature: **Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C)**.
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

E. Construction:

1. Linkage out of airstream.
2. Suitable for horizontal or vertical airflow applications.
3. Frames:
 - a. Hat, U, or angle shaped.
 - b. Frame Thickness: **[0.08-inch- (2.0-mm-) thick extruded aluminum][16-gauge- (1.6-mm-) thick, galvanized sheet steel][18-gauge- (1.3-mm-) thick stainless steel]**.
 - c. Corners: **[Mitered and welded][Interlocking, gusseted]**.

- d. Flanges for attaching to walls and flangeless frames for installing in ducts.
- 4. Blades:
 - a. Multiple blade with maximum blade width of **[6 inches (150 mm)][8 inches (200 mm)]**.
 - b. Blade Design: **[Parallel][Opposed]** blade.
 - c. Blade Material: **[Galvanized steel][Stainless steel][Aluminum]**.
 - d. Blade Thickness: **[16-gauge- (1.6-mm-) thick single skin][or][14-gauge- (1.9-mm-) thick air foil dual skin]**.
- 5. Blade Edging Seals:
 - a. Replaceable **[closed-cell neoprene][PVC]**.
 - b. Inflatable seal blade edging, or replaceable rubber seals.
- 6. Blade Jamb Seal: Flexible stainless steel, compression type.
- 7. Blade Axles: **1/2-inch (13-mm)** diameter; **[galvanized][stainless]** steel.
- 8. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.
- 9. Bearings: **[Oil-impregnated bronze][Molded synthetic][Oil-impregnated stainless steel sleeve][Stainless steel sleeve]**.
 - a. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

F. Damper Actuator - Electric:

- 1. Electric - **[120 V ac][24 V ac]**.
- 2. UL 60730-2-14 and UL 2043, plenum rated.
- 3. Actuator Type: **[Two position][Fully modulating][with fail-safe spring return]**.
 - a. Sufficient motor torque **[and spring torque]** to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Minimum 90-degree drive rotation.
- 4. Clockwise or counterclockwise drive rotation as required for application.
- 5. Environmental Operating Range:
 - a. Temperature: **Minus 40 to plus 130 deg F (Minus 40 to plus 55 deg C)**.
 - b. Humidity: 5 to 95 percent relative humidity noncondensing.
- 6. Environmental enclosure: NEMA 2.
- 7. Actuator to be factory mounted and provided with a single-point wiring connection.

G. Damper Actuator - Pneumatic:

- 1. Operated by **0 to 20 psig (0 to 138 kPa)** pneumatic signal.
- 2. Actuator Type: **[Two position with][Fully modulating with positioner and][with fail-safe spring return]**.
 - a. Sufficient power and spring force to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Maximum 15-second full-stroke closure.
- 3. Actuator to be factory mounted.

H. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: **[115 V, single phase, 60 Hz][24 V, 60 Hz]<Insert values>**.

2.5 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Air Balance; MESTEK, Inc.]**
2. **[Aire Technologies, Inc.; DMI Companies]**
3. **[Arrow United Industries; Mestek, Inc.]**
4. **[Cesco Products; MESTEK, Inc.]**
5. **[CL WARD & Family Inc.]**
6. **[Greenheck Fan Corporation]**
7. **[NCA Manufacturing, Inc.; Metal Industries, Inc.]**
8. **[Pottorff]**
9. **[Prefco]**
10. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
11. **[Safe Air - Dowco]**
12. **[United Enertech Corp.]**
13. **[Vent Products Co., Inc]**
14. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Air Balance; MESTEK, Inc.]**
2. **[Aire Technologies, Inc.; DMI Companies]**
3. **[Arrow United Industries; Mestek, Inc.]**
4. **[Cesco Products; MESTEK, Inc.]**
5. **[CL WARD & Family Inc.]**
6. **[Greenheck Fan Corporation]**
7. **[NCA Manufacturing, Inc.; Metal Industries, Inc.]**
8. **[Pottorff]**
9. **[Prefco]**
10. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
11. **[Safe Air - Dowco]**
12. **[United Enertech Corp.]**
13. **[Vent Products Co., Inc]**
14. **<Insert manufacturer's name>**

C. Standards: Comply with NFPA 90A and NFPA 90B.

D. Type: **[Static][and][dynamic]**; rated and labeled in accordance with UL 555 by an NRTL.

E. Closing rating in ducts up to **[4 inch wg (1 kPa)]<Insert value>** static pressure class and minimum **[2000 fpm (1 m/s)]<Insert value>** velocity.

F. Fire Rating: **[1-1/2][and][3]** hours.

G. Frame: **[Curtain type with blades inside airstream][Curtain type with blades outside**



airstream][Multiple-blade type][Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream]; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.

- H. Mounting Sleeve: Factory- or field-installed, **[galvanized sheet][stainless]** steel; gauge in accordance with UL listing.
- I. Mounting Orientation: Vertical or horizontal as indicated.
- J. Blades: Roll-formed **[galvanized sheet steel][stainless steel]**, **[interlocking][full-length steel blade connectors]**. Material gauge is to be in accordance with UL listing.
- K. Horizontal Dampers: Include blade lock and stainless steel closure spring.
- L. Heat-Responsive Device:
 - 1. Replaceable, **[165 deg F (74 deg C)][212 deg F (100 deg C)]<Insert temperature>** rated, fusible links.
 - 2. **[Electric][Pneumatic]**, **[resettable][replaceable]** link and switch package, factory installed, **[165 deg F (74 deg C)][and][212 deg F (100 deg C)]<Insert temperature>** rated.

2.6 CEILING RADIATION DAMPERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Air Balance; MESTEK, Inc.]**
 - 2. **[Aire Technologies, Inc.; DMI Companies]**
 - 3. **[Arrow United Industries; Mestek, Inc.]**
 - 4. **[Cesco Products; MESTEK, Inc.]**
 - 5. **[CL WARD & Family Inc.]**
 - 6. **[Greenheck Fan Corporation]**
 - 7. **[Lloyd Industries, Inc.]**
 - 8. **[Nailor Industries Inc]**
 - 9. **[NCA Manufacturing, Inc.; Metal Industries, Inc.]**
 - 10. **[Pottorff]**
 - 11. **[Prefco]**
 - 12. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 13. **[Safe Air - Dowco]**
 - 14. **[United Enertech Corp.]**
 - 15. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Air Balance; MESTEK, Inc.]**
 - 2. **[Aire Technologies, Inc.; DMI Companies]**
 - 3. **[Arrow United Industries; Mestek, Inc.]**
 - 4. **[Cesco Products; MESTEK, Inc.]**
 - 5. **[CL WARD & Family Inc.]**
 - 6. **[Greenheck Fan Corporation]**
 - 7. **[Lloyd Industries, Inc.]**
 - 8. **[Nailor Industries Inc]**

9. [NCA Manufacturing, Inc.; Metal Industries, Inc.]
10. [Pottorff]
11. [Prefco]
12. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
13. [Safe Air - Dowco]
14. [United Enertech Corp.]
15. <Insert manufacturer's name>

C. Standards: Comply with NFPA 90A and NFPA 90B.

D. General Requirements:

1. Labeled according to UL 555C by an NRTL.
2. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

E. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction; gauge in accordance with UL listing.

F. Blades: Galvanized sheet steel with refractory insulation; gauge in accordance with UL listing.

G. Heat-Responsive Device: Replaceable, [165 deg F (74 deg C)][212 deg F (100 deg C)]<Insert temperature> rated, fusible links.

H. Fire Rating: [1][2][3]<Insert number> hour(s).

2.7 SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Air Balance; MESTEK, Inc.]
2. [Aire Technologies, Inc.; DMI Companies]
3. [Arrow United Industries; Mestek, Inc.]
4. [Cesco Products; MESTEK, Inc.]
5. [CL WARD & Family Inc.]
6. [Greenheck Fan Corporation]
7. [Pottorff]
8. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
9. [Safe Air - Dowco]
10. [United Enertech Corp.]
11. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Air Balance; MESTEK, Inc.]
2. [Aire Technologies, Inc.; DMI Companies]
3. [Arrow United Industries; Mestek, Inc.]
4. [Cesco Products; MESTEK, Inc.]
5. [CL WARD & Family Inc.]
6. [Greenheck Fan Corporation]
7. [Pottorff]
8. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]

9. [Safe Air - Dowco]
10. [United Enertech Corp.]
11. <Insert manufacturer's name>

C. General Requirements:

1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
2. Label to indicate conformance to NFPA 80, NFPA 90A, and NFPA 90B by an NRTL.
3. Unless otherwise indicated, use parallel-blade configuration.
4. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.
5. Factory install damper actuator by damper manufacturer as integral part of damper assembly. Coordinate actuator location, mounting, and electrical requirements with damper manufacturer.

D. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA 511.
2. Leakage:
 - a. Class IA: Leakage is not to exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 - b. Class I: Leakage is not to exceed **4 cfm/sq. ft. (20 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 - c. Class II: Leakage is not to exceed **10 cfm/sq. ft. (51 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
3. Pressure Drop: **0.05 inch wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to **[3000 fpm (15 m/s)]<Insert velocity>**.
5. Temperature: **Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C)**.
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

E. Construction:

1. Suitable for horizontal or vertical airflow applications.
2. Linkage out of airstream.
3. Frame:
 - a. Hat shaped.
 - b. **[Galvanized sheet steel][Stainless steel]**, with **[welded][interlocking, gusseted][or][mechanically attached]** corners **[and mounting flange]**.
 - c. Gauge in accordance with UL listing.
4. Blades:
 - a. Roll-formed, horizontal, **[v-groove][airfoil]**, **[galvanized sheet steel][stainless steel][extruded aluminum]**.
 - b. Maximum width and gauge in accordance with UL listing.
5. Blade Edging Seals:
 - a. Silicone rubber.
6. Blade Jamb Seal: Flexible stainless steel, compression type.

7. Blade Axles: **1/2-inch (13-mm)** diameter; **[galvanized steel][stainless steel]**; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage is to be mounted out of airstream.
 8. Bearings: **[Oil-impregnated bronze][Molded synthetic][Oil-impregnated stainless steel sleeve][Stainless steel sleeve]**.
- F. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application **[with factory-furnished silicone caulking]**; gauge in accordance with UL listing.
- G. Damper Actuator - Electric:
1. Electric - **[120 V ac][24 V ac]**.
 2. UL 60730-2-14 and UL 2043, plenum rated.
 3. Designed to operate in smoke-control systems complying with UL 555S requirements.
 4. Actuator Type: **[Two position][Fully modulating][with fail-safe spring return]**.
 - a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Maximum 15-second full-stroke closure.
 - c. Minimum 90-degree drive rotation.
 5. Clockwise or counterclockwise drive rotation as required for application.
 6. Environmental Operating Range:
 - a. Temperature: **Minus 40 to plus 130 deg F (Minus 40 to plus 55 deg C)**.
 - b. Humidity: 5 to 95 percent relative humidity noncondensing.
 7. Environmental Enclosure: NEMA 2.
 8. Actuator to be factory mounted and provided with single-point wiring connection.
- H. Damper Actuator - Pneumatic:
1. Operated by **0 to 20 psig (0 to 138 kPa)** pneumatic signal.
 2. Designed to operate in smoke-control systems complying with UL 555S requirements.
 3. Actuator Type: **[Two position with][Fully modulating with positioner and]** fail-safe spring return.
 - a. Sufficient power and spring force to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Maximum 15-second full-stroke closure.
 4. Actuator to be factory mounted.
- I. Controllers, Electrical Devices, and Wiring:
1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 2. Electrical Connection: **[115 V, single phase, 60 Hz][24 V, 60 Hz]<Insert values>**.
- J. Accessories:
1. Auxiliary switches for **[signaling][fan control][or][position indication]**.
 2. **[Momentary test switch][Test and reset switches]**, **[damper][remote]** mounted.
 3. Smoke Detector: Integral, factory wired for single-point connection.

2.8 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Air Balance; MESTEK, Inc.]**
 2. **[Aire Technologies, Inc.; DMI Companies]**
 3. **[Arrow United Industries; Mestek, Inc.]**
 4. **[Cesco Products; MESTEK, Inc.]**
 5. **[CL WARD & Family Inc.]**
 6. **[Greenheck Fan Corporation]**
 7. **[NCA Manufacturing, Inc.; Metal Industries, Inc.]**
 8. **[Pottorff]**
 9. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 10. **[Safe Air - Dowco]**
 11. **[United Enertech Corp.]**
 12. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Air Balance; MESTEK, Inc.]**
 2. **[Aire Technologies, Inc.; DMI Companies]**
 3. **[Arrow United Industries; Mestek, Inc.]**
 4. **[Cesco Products; MESTEK, Inc.]**
 5. **[CL WARD & Family Inc.]**
 6. **[Greenheck Fan Corporation]**
 7. **[NCA Manufacturing, Inc.; Metal Industries, Inc.]**
 8. **[Pottorff]**
 9. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 10. **[Safe Air - Dowco]**
 11. **[United Enertech Corp.]**
 12. **<Insert manufacturer's name>**
- C. General Requirements:
1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
 2. Label to indicate conformance to NFPA 80, NFPA 90A, and NFPA 90B by an NRTL.
 3. Unless otherwise indicated, use parallel-blade configuration.
- D. Closing rating in ducts up to **[4 inch wg (1 kPa)]<Insert value>** static pressure class and minimum **[2000 fpm (10 m/s)]<Insert value>** velocity.
- E. Fire Rating: **[1-1/2][and][3]** hours.
- F. Performance:
1. AMCA Certification: Test and rate in accordance with AMCA 511.
 2. Leakage:
 - a. Class IA: Leakage is not to exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 - b. Class I: Leakage is not to exceed **4 cfm/sq. ft. (20 L/s/ per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.

- c. Class II: Leakage is not to exceed **10 cfm/sq. ft. (51 L/s per sq. m)** against **1 inch wg (250 Pa)** differential static pressure.
 3. Pressure Drop: **0.05 in. wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, Figure 5.3.
 4. Velocity: Up to **3000 fpm (15 m/s)**.
 5. Temperature: **Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C)**.
 6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
- G. Construction:
 1. Suitable for horizontal or vertical airflow applications.
 2. Linkage out of airstream.
 3. Frame:
 - a. Hat shaped.
 - b. **[Galvanized sheet steel][Stainless steel]**, with **[welded][interlocking, gusseted][or][mechanically attached]** corners **[and mounting flange]**.
 - c. Gauge is to be in accordance with UL listing.
 4. Blades:
 - a. Roll-formed, horizontal, **[v-groove][airfoil]**, **[galvanized sheet steel][stainless steel][extruded aluminum]**.
 - b. Maximum width and gauge in accordance with UL listing.
 5. Blade Edging Seals:
 - a. Silicone rubber.
 6. Blade Jamb Seal: Flexible stainless steel, compression type.
 7. Blade Axles: **1/2-inch- (13-mm-)** diameter; **[galvanized steel][stainless steel]**; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of airstream.
 8. Bearings: **[Oil-impregnated bronze][Molded synthetic][Oil-impregnated stainless steel sleeve][Stainless steel sleeve]**.
- H. Mounting Sleeve:
 1. Factory installed, galvanized sheet steel.
 2. Length to suit wall or floor application **[with factory-furnished silicone caulking]**.
 3. Gauge in accordance with UL listing.
- I. Heat-Responsive Device:
 1. **[Resettable][Replaceable]**, **[165 deg F (74 deg C)][212 deg F (100 deg C)]** rated, **[fusible links][fire-closure device]**.
 2. **[Electric][Pneumatic]** resettable **[link][device]** and switch package, factory installed, rated.
- J. Master control panel for use in dynamic smoke-management systems.
- K. Damper Actuator - Electric:
 1. Electric - **[120 V ac][24 V ac]**.
 2. UL 60730-2-14 and UL 2043, plenum rated.



3. Designed to operate in smoke-control systems complying with UL 555S requirements.
4. Actuator Type: **[Two position][Fully modulating]** with fail-safe spring return.
 - a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Maximum 15-second full-stroke closure.
 - c. Minimum 90-degree drive rotation.
5. Clockwise or counterclockwise drive rotation as required for application.
6. Environmental Operating Range:
 - a. Temperature: **Minus 40 to plus 130 deg F (Minus 40 to plus 55 deg C).**
 - b. Humidity: 5 to 95 percent relative humidity noncondensing.
7. Environmental Enclosure: NEMA 2.
8. Actuator to be factory mounted and provided with single-point wiring connection.

L. Damper Actuator - Pneumatic:

1. Operated by **0 to 20 psig (0 to 138 kPa)** pneumatic signal.
2. Designed to operate in smoke control systems complying with UL 555S requirements.
3. Actuator Type: **[Two position with][Fully modulating with positioner and]** fail-safe spring return.
 - a. Sufficient power and spring force to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Maximum 15-second full-stroke closure.
4. Actuator to be factory mounted.

M. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: **[115 V, single phase, 60 Hz][24 V, 60 Hz]<Insert values>.**

N. Accessories:

1. Auxiliary switches for **[signaling][fan control][or][position indication]**.
2. **[Momentary test switch][Test and reset switches]**, **[damper][remote]** mounted.
3. Smoke Detector: Integral, factory wired for single-point connection.

2.9 CORRIDOR DAMPERS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Aire Technologies, Inc.; DMI Companies]**
2. **[Cesco Products; MESTEK, Inc.]**
3. **[Pottorff]**
4. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
5. **[Safe Air - Dowco]**

6. [United Enertech Corp.]
 7. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Aire Technologies, Inc.; DMI Companies]
 2. [Cesco Products; MESTEK, Inc.]
 3. [Pottorff]
 4. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 5. [Safe Air - Dowco]
 6. [United Enertech Corp.]
 7. <Insert manufacturer's name>
- C. General Requirements:
1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
 2. Label to indicate conformance to NFPA 90A by an NRTL.
- D. Closing rating in ducts up to [4 inch wg (1 kPa)]<Insert value> static pressure class and minimum [2000 fpm (10 m/s)]<Insert value> velocity.
- E. Fire Rating: [1][1-1/2][2] hour(s).
- F. Performance:
1. AMCA Certification: Test and rate in accordance with AMCA 511.
 2. Leakage:
 - a. Class 1A: Leakage is not to exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1 inch wg (250 Pa) differential static pressure.
 - b. Class 1: Leakage is not to exceed 4 cfm/sq. ft. (20 L/s/ per sq. m) against 1 inch wg (250 Pa) differential static pressure.
 - c. Class II: Leakage is not to exceed 10 cfm/sq. ft. (51 L/s per sq. m) against 1 inch wg (250 Pa) differential static pressure.
- G. Construction:
1. Frame: Hat shaped, galvanized sheet steel, with [welded][interlocking, gusseted][or][mechanically attached] corners[and mounting flange]; gauge in accordance with UL listing.
 2. Blades: Roll-formed, horizontal, [interlocking][overlapping], galvanized sheet steel; gauge in accordance with UL listing.
- H. Mounting Sleeve:
1. Factory installed, galvanized sheet steel.
 2. Length to suit wall or floor application[with factory-furnished silicone caulking].
 3. Gauge in accordance with UL listing.
- I. Heat-Responsive Device:
1. [Resettable][Replaceable], [165 deg F (74 deg C)][212 deg F (100 deg C)] rated, [fusible links][fire-closure device].
 2. [Electric][Pneumatic] resettable [link][device] and switch package, factory installed, rated.

J. Damper Actuator - Electric:

1. Electric - **[120 V ac][24 V ac]**.
2. UL 60730-2-14 and UL 2043, plenum rated.
3. Designed to operate in smoke-control systems complying with UL 555S requirements.
4. Actuator Type: Two position with fail-safe spring return.
 - a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Maximum 15-second full-stroke closure.
 - c. Minimum 90-degree drive rotation.
5. Clockwise or counterclockwise drive rotation as required for application.
6. Environmental Operating Range:
 - a. Temperature: **Minus 40 to plus 130 deg F (Minus 40 to plus 55 deg C)**.
 - b. Humidity: 5 to 95 percent relative humidity noncondensing.
7. Environmental enclosure: NEMA 2.
8. Actuator to be factory mounted and provided with single-point wiring connection.

K. Damper Actuator - Pneumatic:

1. Operated by **0 to 20 psig (0 to 138 kPa)** pneumatic signal.
2. Designed to operate in smoke-control systems complying with UL 555S requirements.
3. Actuator Type: Two position with fail-safe spring return.
 - a. Sufficient power and spring force to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Maximum 15-second full-stroke closure.
4. Actuator to be factory mounted.

L. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: **[115 V, single phase, 60 Hz][24 V, 60 Hz]<Insert values>**.

M. Accessories:

1. Auxiliary switches for **[signaling][fan control][or][position indication]**.
2. **[Momentary test switch][Test and reset switches]**, **[damper][remote]** mounted.
3. Smoke Detector: Integral, factory wired for single-point connection.

2.10 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[CL WARD & Family Inc.]**
2. **[Ductmate Industries, Inc; a DMI company]**

3. [DynAir; a Carlisle Company]
4. [Elgen Manufacturing]
5. [Ward Industries; a brand of Hart & Cooley, LLC]
6. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [CL WARD & Family Inc.]
2. [Ductmate Industries, Inc; a DMI company]
3. [DynAir; a Carlisle Company]
4. [Elgen Manufacturing]
5. [Ward Industries; a brand of Hart & Cooley, LLC]
6. <Insert manufacturer's name>

C. Description: [Add-on][or][roll-formed], factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

D. Material: Galvanized steel.

E. Gauge and Shape: Match connecting ductwork.

2.11 DUCT-MOUNTED DUCT SILENCERS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [FläktGroup]
2. [Flexmaster U.S.A., Inc]
3. [IAC Acoustics]
4. [McGill AirFlow LLC]
5. [Metal Form Manufacturing LLC; United Enertech Corp.]
6. [Pottorff]
7. [Price Industries Limited]
8. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
9. [Vibro-Acoustics]
10. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [FläktGroup]
2. [Flexmaster U.S.A., Inc]
3. [IAC Acoustics]
4. [McGill AirFlow LLC]
5. [Metal Form Manufacturing LLC; United Enertech Corp.]
6. [Pottorff]
7. [Price Industries Limited]
8. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
9. [Vibro-Acoustics]
10. <Insert manufacturer's name>

C. General Requirements:

1. Factory fabricated.
 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials are to have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
 3. Airstream Surfaces: Surfaces in contact with the airstream are to comply with requirements in ASHRAE 62.1.
 4. Bearing AMCA's Certified Ratings Seal for prefabricated silencer sound and air performance.
- D. Shape:
1. Rectangular straight with splitters or baffles.
 2. Round straight with center bodies or pods.
 3. Rectangular elbow with splitters or baffles.
 4. Round elbow with center bodies or pods.
 5. Rectangular transitional with splitters or baffles.
- E. Rectangular Silencer Outer Casing: ASTM A653/A653M, [G90 (Z275)][G60 (Z180)], galvanized sheet steel, [0.034 inch (0.85 mm)][0.040 inch (1.02 mm)]<Insert dimension> thick.
- F. Round Silencer Outer Casing: ASTM A653/A653M, [G90 (Z275)][G60 (Z180)], galvanized sheet steel.
1. Sheet Metal Thickness for Units up to **24 Inches (600 mm)** in Diameter: [22 gauge (0.85 mm)]<Insert value> thick.
 2. Sheet Metal Thickness for Units **26 through 40 Inches (660 through 1000 mm)** in Diameter: [20 gauge (1.02 mm)]<Insert value> thick.
 3. Sheet Metal Thickness for Units **42 through 52 Inches (1060 through 1300 mm)** in Diameter: [18 gauge (1.3 mm)]<Insert value> thick.
 4. Sheet Metal Thickness for Units **54 through 60 Inches (1370 through 1500 mm)** in Diameter: [16 gauge (1.62 mm)]<Insert value> thick.
- G. Inner Casing and Baffles: ASTM A653/A653M, [G90 (Z275)][G60 (Z180)] galvanized sheet metal, [22 gauge (0.85 mm)]<Insert value> thick, and with [1/8-inch- (3-mm-)]<Insert dimension> diameter perforations.
- H. Special Construction:
1. Suitable for outdoor use.
 2. High transmission loss[**to achieve STC 45**]<Insert value>.
- I. Connection Sizes: Match connecting ductwork unless otherwise indicated.
- J. Principal Sound-Absorbing Mechanism:
1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
 2. [Dissipative][Film-lined] type with fill material.
 - a. Fill Material: [Inert and vermin-proof fibrous material, packed under not less than 5 percent compression][Inert and vermin-proof fibrous material, packed under not less than 15 percent compression][Moisture-proof nonfibrous material].
 - b. Erosion Barrier: Polymer bag enclosing fill, heat-sealed before assembly.
 3. Lining: [None][Mylar][Tedlar][Fiberglas cloth]<Insert material>.
- K. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints: **[Lock formed and sealed][Continuously welded][or][flanged connections]**.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

L. Accessories:

1. Integral **[1-1/2][3]**-hour fire damper with access door. **[Access door to be high transmission loss to match silencer.]**
2. Factory-installed end caps to prevent contamination during shipping.
3. Removable splitters.
4. Airflow-measuring devices.

M. Source Quality Control:

1. Test in accordance with ASTM E477.
2. Testing **[of mockups]** to be witnessed by **[Architect][Owner]**.
3. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least **[2000 fpm (10 m/s)]<Insert value>** face velocity.
4. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or **[6-inch wg (1500-Pa)]<Insert value>** static pressure, whichever is greater.

N. Capacities and Characteristics:

1. Configuration: **[Straight][90-degree elbow]<Insert configuration>**.
2. Shape: **[Rectangular][Round]**.
3. Attenuation Mechanism: **[Acoustical glass fiber][Acoustical glass fiber with protective film liner][Helmholtz resonator mechanism with no internal media]**.
4. Maximum Pressure Drop: **[0.35 inch wg (0.09 kPa)]<Insert value>**.
5. Casing:
 - a. Attenuation: **[Standard][High transmission loss]**.
 - b. Outer Material: **[Galvanized steel][Stainless steel][Aluminum]**.
 - c. Inner Material: **[Galvanized steel][Stainless steel][Aluminum]**.
6. Velocity Range: **<Insert fps (L/s)> to <Insert fps (L/s)>**.
7. End Connection: **[1-inch (25-mm) slip joint][Flange]**.
8. Length: **<Insert inches (mm)>**.
9. Face Dimension:
 - a. Width: **<Insert inches (mm)>**.
 - b. Height: **<Insert inches (mm)>**.
10. Face Velocity: **<Insert fpm (m/s)>**.
11. Dynamic Insertion Loss: **<Insert dBA>**.
12. Generated Noise: **<Insert dBA>**.
13. Accessories:
 - a. Access door.
 - b. Birdscreen.

2.12 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be**

incorporated into the Work include, but are not limited to, the following]:

1. [Aero-Dyne Sound Control Co.]
2. [CL WARD & Family Inc.]
3. [Ductmate Industries, Inc; a DMI company]
4. [Duro Dyne Inc.]
5. [DynAir; a Carlisle Company]
6. [Elgen Manufacturing]
7. [Ward Industries; a brand of Hart & Cooley, LLC]
8. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Aero-Dyne Sound Control Co.]
2. [CL WARD & Family Inc.]
3. [Ductmate Industries, Inc; a DMI company]
4. [Duro Dyne Inc.]
5. [DynAir; a Carlisle Company]
6. [Elgen Manufacturing]
7. [Ward Industries; a brand of Hart & Cooley, LLC]
8. <Insert manufacturer's name>

- C. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Turning Vanes: Fabricate [single][double]-wall curved blades of [galvanized steel][stainless steel][aluminum][extruded aluminum].
2. Acoustic Turning Vanes: Fabricate airfoil-shaped [galvanized steel][sheet aluminum][extruded aluminum] with perforated faces and fibrous-glass fill.

- D. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

- E. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

- F. Vane Construction:

1. Wall: [Single][Double].
2. Single wall for ducts up to [48 inches (1200 mm)]<Insert dimension> wide and double wall for larger dimensions.

2.13 REMOTE DAMPER OPERATORS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [DynAir; a Carlisle Company]
2. [METALAIR, Inc]
3. [United Enertech Corp.]
4. [Young Regulator Company]

5. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [DynAir; a Carlisle Company]
2. [METALAIRE, Inc]
3. [United Enertech Corp.]
4. [Young Regulator Company]
5. <Insert manufacturer's name>

C. Description: Cable system designed for remote manual damper adjustment.

D. Tubing: [Brass][Copper][Aluminum].

E. Cable: [Stainless steel][Steel].

F. Wall-Box Mounting: [Recessed][Surface].

G. Wall-Box Cover-Plate Material: [Steel][Stainless steel].

2.14 DUCT-MOUNTED ACCESS DOORS AND PRESSURE-RELIEF DOORS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Aire Technologies, Inc.; DMI Companies]
2. [Arrow United Industries; Mestek, Inc.]
3. [Cesco Products; MESTEK, Inc.]
4. [CL WARD & Family Inc.]
5. [Ductmate Industries, Inc; a DMI company]
6. [Duro Dyne Inc.]
7. [Elgen Manufacturing]
8. [Flexmaster U.S.A., Inc]
9. [McGill AirFlow LLC]
10. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
11. [United Enertech Corp.]
12. [Ventfabrics, Inc]
13. [Ward Industries; a brand of Hart & Cooley, LLC]
14. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Aire Technologies, Inc.; DMI Companies]
2. [Arrow United Industries; Mestek, Inc.]
3. [Cesco Products; MESTEK, Inc.]
4. [CL WARD & Family Inc.]
5. [Ductmate Industries, Inc; a DMI company]
6. [Duro Dyne Inc.]
7. [Elgen Manufacturing]
8. [Flexmaster U.S.A., Inc]
9. [McGill AirFlow LLC]
10. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]

11. [United Enertech Corp.]
12. [Ventfabrics, Inc]
13. [Ward Industries; a brand of Hart & Cooley, LLC]
14. <Insert manufacturer's name>

C. General Requirements: Fabricate [access doors][pressure-relief doors] in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."

D. Access Doors:

1. Door:
 - a. Double wall, rectangular.
 - b. Material matching duct material, with insulation fill matching duct insulation type and thickness, and access door wall thickness matching duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: **1-by-1-inch (25-by-25-mm)** butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
2. Frame: Material matching door material, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches (460 mm) Square: **[Two hinges][Continuous]** and two sash locks.
 - c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): **[Three hinges][Continuous]** and two compression latches **[with outside and inside handles]**.
 - d. Access Doors Larger than 24 by 48 Inches (600 by 1200 mm): **[Four hinges][Continuous]** and two compression latches with outside and inside handles.

E. Pressure-Relief Doors:

1. Door and Frame Material: **[24-gauge- (0.70-mm-) thick galvanized steel][or][0.032-inch- (0.81-mm-) thick aluminum][or][24-gauge- (0.70-mm-) thick stainless steel]**<Insert material and thickness> door panel.
2. Door Wall: **[Single wall][Double wall with insulation fill]** with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at **[3.0 to 8.0 inches wg (800 to 2000 Pa)][10 inches wg (2500 Pa)]**<Insert value>.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: **[1-inch- (25-mm-)]**<Insert dimension> thick, fibrous-glass or polystyrene-foam board.

2.15 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. [CL WARD & Family Inc.]

2. [Ductmate Industries, Inc; a DMI company]
 3. [Flame Gard, Inc]
 4. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [CL WARD & Family Inc.]
 2. [Ductmate Industries, Inc; a DMI company]
 3. [Flame Gard, Inc]
 4. <Insert manufacturer's name>
- C. Access panels used in cooking applications:
1. Labeled compliant to NFPA 96 for grease duct access doors.
 2. Labeled in accordance with UL 1978 by an NRTL.
- D. Panel and Frame: Minimum thickness [16-gauge (1.6-mm) carbon][16-gauge (1.6-mm) stainless]<Insert value and steel type> steel.
- E. Fasteners: [Carbon][Stainless] steel. Panel fasteners are not to penetrate duct wall.
- F. Gasket: Comply with NFPA 96, grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).
- G. Minimum Pressure Rating: [10 inches wg (2500 Pa)]<Insert value> positive or negative.

2.16 DUCT FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [CL WARD & Family Inc.]
 2. [Ductmate Industries, Inc; a DMI company]
 3. [Duro Dyne Inc.]
 4. [DynAir; a Carlisle Company]
 5. [Elgen Manufacturing]
 6. [Ventfabrics, Inc]
 7. [Ward Industries; a brand of Hart & Cooley, LLC]
 8. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [CL WARD & Family Inc.]
 2. [Ductmate Industries, Inc; a DMI company]
 3. [Duro Dyne Inc.]
 4. [DynAir; a Carlisle Company]
 5. [Elgen Manufacturing]
 6. [Ventfabrics, Inc]
 7. [Ward Industries; a brand of Hart & Cooley, LLC]
 8. <Insert manufacturer's name>

- C. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials are to

have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.

- D. Airstream Surfaces: Surfaces in contact with the airstream are to comply with requirements in ASHRAE 62.1.
- E. Materials: Flame-retardant or noncombustible fabrics.
- F. Coatings and Adhesives: Comply with UL 181, Class 1.
- G. Metal-Edged Connectors: Factory fabricated with a fabric strip [3-1/2 inches (89 mm)][5-3/4 inches (146 mm)]<Insert dimension> wide attached to two strips of 2-3/4-inch- (70-mm-) wide, [0.028-inch- (0.7-mm-)]<Insert dimension> thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.
- H. Indoor System, Duct Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: [26 oz./sq. yd. (880 g/sq. m)]<Insert value>.
 - 2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and [360 lbf/inch (63 N/mm)]<Insert value> in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
- I. Outdoor System, Duct Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: [24 oz./sq. yd. (810 g/sq. m)]<Insert value>.
 - 2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and [440 lbf/inch (77 N/mm)]<Insert value> in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).
- J. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - 1. Minimum Weight: [16 oz./sq. yd. (542 g/sq. m)]<Insert value>.
 - 2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and [185 lbf/inch (32 N/mm)]<Insert value> in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
- K. High-Corrosive-Environment System, Duct Flexible Connectors: Glass fabric with chemical-resistant coating.
 - 1. Minimum Weight: [14 oz./sq. yd. (474 g/sq. m)]<Insert value>.
 - 2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and [340 lbf/inch (60 N/mm)]<Insert value> in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
- L. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 - 1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or

- failure.
- 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
- 7. Coil Spring: Factory set and field adjustable for a maximum of [1/4-inch (6-mm)]<Insert dimension> movement at start and stop.

2.17 DUCT SECURITY BARS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. [Carnes Company]
 - 2. [Kees, Inc]
 - 3. [Lloyd Industries, Inc.]
 - 4. [Metal Form Manufacturing LLC; United Enertech Corp.]
 - 5. [Price Industries Limited]
 - 6. [United Enertech Corp.]
 - 7. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. [Carnes Company]
 - 2. [Kees, Inc]
 - 3. [Lloyd Industries, Inc.]
 - 4. [Metal Form Manufacturing LLC; United Enertech Corp.]
 - 5. [Price Industries Limited]
 - 6. [United Enertech Corp.]
 - 7. <Insert manufacturer's name>
- C. Description: [Field-fabricated][Factory-fabricated and field-installed][Field- or factory-fabricated and field-installed] duct security bars.
- D. Configuration:
 - 1. Frame Size: [Flat frame of 2 by 1/4 inch (50 by 6 mm)][Angle frame of 2-1/2 by 2-1/2 by 1/4 inch (64 by 64 by 6 mm)]<Insert values>.
 - 2. Sleeve: [0.1345-inch (3.4-mm)][3/16-inch (4.8-mm)]<Insert size>, [continuously welded][bent] steel frames with [1-by-1-by-3/16-inch (25-by-25-by-4.8-mm)][1-1/2-by-1-1/2-by-1/8-inch (38-by-38-by-3-mm)]<Insert size> angle frame [factory welded to one end][furnished loose for field welding on other end]. To be poured in place or set with concrete block or welded or bolted to wall, one side only. Duct connections on both sides.
 - 3. Horizontal Bars: [1/2 inch (13 mm)][2 by 1/4 inch (50 by 6 mm)]<Insert dimensions>.
 - 4. Vertical Bars: [1/2 inch (13 mm)][3/4 inch (19 mm)][1 inch (25 mm)][2 by 1/4 inch (50 by 6 mm)]<Insert dimension(s)>.
 - 5. Bar Spacing: [6 inches (150 mm)]<Insert dimension>.
 - 6. Mounting: [Metal deck or roofing][Bolted or welded][Bolted or welded with masonry anchors][Ductwork or other framing][Poured in place or set with concrete block][Welded or bolted to one wall (one side only)][Bar extends 6 inches (150 mm) into wall].

2.18 DUCT ACCESSORY HARDWARE

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be

incorporated into the Work include, but are not limited to, the following]:

1. [CL WARD & Family Inc.]
2. [Ductmate Industries, Inc; a DMI company]
3. [Duro Dyne Inc.]
4. [DynAir; a Carlisle Company]
5. [Elgen Manufacturing]
6. [Hardcast; Carlisle Construction Materials]
7. [United Enertech Corp.]
8. [Ventfabrics, Inc]
9. [Ward Industries; a brand of Hart & Cooley, LLC]
10. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [CL WARD & Family Inc.]
2. [Ductmate Industries, Inc; a DMI company]
3. [Duro Dyne Inc.]
4. [DynAir; a Carlisle Company]
5. [Elgen Manufacturing]
6. [Hardcast; Carlisle Construction Materials]
7. [United Enertech Corp.]
8. [Ventfabrics, Inc]
9. [Ward Industries; a brand of Hart & Cooley, LLC]
10. <Insert manufacturer's name>

C. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

D. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.19 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: [G60 (Z180)][G90 (Z275)].
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a [No. 2]<Insert finish designation> finish for concealed ducts and <Insert finish designation> finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B209/B209M, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with **ASTM B221 (ASTM B221M)**, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

F. Tie Rods: Galvanized steel, [1/4-inch (6-mm)]<Insert dimension> minimum diameter for lengths 36 inches (900 mm) or less; [3/8-inch (10-mm)]<Insert dimension> minimum diameter for lengths

longer than **36 inches (900 mm)**.

2.20 FLEXIBLE DUCTS, NONINSULATED

- A. Standard: Product is to be UL 181 listed and bearing the UL label.
- B. Flexible Ducts, Noninsulated - Class 1, Two-Ply Vinyl or Polyethylene Film Supported by Helically Wound, Spring-Steel Wire:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Flexmaster U.S.A., Inc]**
 - b. **[JP Lamborn Co.]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Flexmaster U.S.A., Inc]**
 - b. **[JP Lamborn Co.]**
 - c. **<Insert manufacturer's name>**
 - 3. Pressure Rating: **10 inch wg (2500 Pa)** positive and **1.0 inch wg (250 Pa)** negative.
 - 4. Maximum Air Velocity: **4000 fpm (20 m/s)**.
 - 5. Temperature Range: **Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C)**.
- C. Flexible Ducts, Noninsulated - Class 1, Black Polymer Film Supported by Helically Wound, Spring-Steel Wire:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Flexmaster U.S.A., Inc]**
 - b. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Flexmaster U.S.A., Inc]**
 - b. **<Insert manufacturer's name>**
 - 3. Pressure Rating: **4 inch wg (1000 Pa)** positive and **0.5 inch wg (125 Pa)** negative.
 - 4. Maximum Air Velocity: **4000 fpm (20 m/s)**.
 - 5. Temperature Range: **Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C)**.
- D. Flexible Ducts, Noninsulated - Class 1, Multiple Layers of Aluminum Laminate Supported by Helically Wound, Spring-Steel Wire:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Flexmaster U.S.A., Inc]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Flexmaster U.S.A., Inc]**
 - b. **<Insert manufacturer's name>**
 3. Pressure Rating: **10 inch wg (2500 Pa)** positive and **1.0 inch wg (250 Pa)** negative.
 4. Maximum Air Velocity: **4000 fpm (20 m/s)**.
 5. Temperature Range: **Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C)**.
- E. Flexible Ducts, Noninsulated - Class 1, Aluminum Laminate and Polyester Film with Latex Adhesive Supported by Helically Wound, Spring-Steel Wire:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Flexmaster U.S.A., Inc]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Flexmaster U.S.A., Inc]**
 - b. **<Insert manufacturer's name>**
 3. Pressure Rating: **10 inch wg (2500 Pa)** positive and **1.0 inch wg (250 Pa)** negative.
 4. Maximum Air Velocity: **4000 fpm (20 m/s)**.
 5. Temperature Range: **Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C)**.
- F. Flexible Ducts, Noninsulated - Class 0, Interlocking Spiral of Aluminum Foil:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ATCO Rubber Products, Inc.]**
 - b. **[Flexmaster U.S.A., Inc]**
 - c. **[Thermaflex; a Flex-Tek Group company]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. [ATCO Rubber Products, Inc.]
 - b. [Flexmaster U.S.A., Inc]
 - c. [Thermaflex; a Flex-Tek Group company]
 - d. <Insert manufacturer's name>
3. Pressure Rating: **8 inch wg (2280 Pa)** positive or negative.
 4. Maximum Air Velocity: **5000 fpm (25 m/s)**.
 5. Temperature Range: **Minus 100 to plus 435 deg F (Minus 73 to plus 224 deg C)**.

2.21 FLEXIBLE DUCTS, INSULATED

- A. Standard: Product is to be UL 181 listed and bearing the UL label.
- B. Flexible Ducts, Insulated - Class 1, Two-Ply Vinyl Film Supported by Helically Wound, Spring-Steel Wire; Fibrous-Glass Insulation:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [ATCO Rubber Products, Inc.]
 - b. [Flexmaster U.S.A., Inc]
 - c. [JP Lamborn Co.]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [ATCO Rubber Products, Inc.]
 - b. [Flexmaster U.S.A., Inc]
 - c. [JP Lamborn Co.]
 - d. <Insert manufacturer's name>
 3. Pressure Rating: **10 inch wg (2500 Pa)** positive and **1.0 inch wg (250 Pa)** negative.
 4. Maximum Air Velocity: **4000 fpm (20 m/s)**.
 5. Temperature Range: **Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C)**.
 6. Insulation R-Value: **[Comply with ASHRAE/IES 90.1][R4.2][R6][R8]<Insert value>**.
 7. Vapor-Barrier Film: **[Polyethylene][Aluminized]**, ASTM E96/E96M.
- C. Flexible Ducts, Insulated - Class 1, Black Polymer Film Supported by Helically Wound, Spring-Steel Wire; Fibrous-Glass Insulation:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [CASCO C.A. Schroeder, Inc.]
 - b. [Flexmaster U.S.A., Inc]
 - c. [JP Lamborn Co.]
 - d. [Thermaflex; a Flex-Tek Group company]

- e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- [CASCO C.A. Schroeder, Inc.]
 - [Flexmaster U.S.A., Inc]
 - [JP Lamborn Co.]
 - [Thermaflex; a Flex-Tek Group company]
 - <Insert manufacturer's name>
3. Pressure Rating: **4 inch wg (1000 Pa)** positive and **0.5 inch wg (125 Pa)** negative.
4. Maximum Air Velocity: **4000 fpm (20 m/s)**.
5. Temperature Range: **Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C)**.
6. Insulation R-Value: [Comply with ASHRAE/IES 90.1][R4.2][R6][R8]<Insert value>.
7. Vapor-Barrier Film: [Polyethylene][Aluminized], ASTM E96/E96M.
- D. Flexible Ducts, Insulated - Class 1, Multiple Layers of Aluminum Laminate Supported by Helically Wound, Spring-Steel Wire; Fibrous-Glass Insulation:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- [Flexmaster U.S.A., Inc]
 - [JP Lamborn Co.]
 - [Thermaflex; a Flex-Tek Group company]
 - <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- [Flexmaster U.S.A., Inc]
 - [JP Lamborn Co.]
 - [Thermaflex; a Flex-Tek Group company]
 - <Insert manufacturer's name>
3. Pressure Rating: **10 inch wg (2500 Pa)** positive and **1.0 inch wg (250 Pa)** negative.
4. Maximum Air Velocity: **4000 fpm (20 m/s)**.
5. Temperature Range: **Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C)**.
6. Insulation R-Value: [Comply with ASHRAE/IES 90.1][R4.2][R6][R8]<Insert value>.
7. Vapor-Barrier Film: [Polyethylene][Aluminized], ASTM E96/E96M.
- E. Flexible Ducts, Insulated - Class 1, Aluminum Laminate and Polyester Film with Latex Adhesive Supported by Helically Wound, Spring-Steel Wire; Fibrous-Glass Insulation:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- [Flexmaster U.S.A., Inc]

- b. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Flexmaster U.S.A., Inc]**
 - b. **<Insert manufacturer's name>**
 - 3. Pressure Rating: **10 inch wg (2500 Pa)** positive and **1.0 inch wg (250 Pa)** negative.
 - 4. Maximum Air Velocity: **4000 fpm (20 m/s)**.
 - 5. Temperature Range: **Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C)**.
 - 6. Insulation R-Value: **[Comply with ASHRAE/IES 90.1][R4.2][R6][R8]<Insert value>**.
 - 7. Vapor-Barrier Film: **[Polyethylene][Aluminized]**, ASTM E96/E96M.
- F. Flexible Ducts, Insulated - Class 0, Interlocking Spiral of Aluminum Foil; Fibrous-Glass Insulation:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Flexmaster U.S.A., Inc]**
 - b. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Flexmaster U.S.A., Inc]**
 - b. **<Insert manufacturer's name>**
 - 3. Pressure Rating: **8 inch wg (2280 Pa)** positive or negative.
 - 4. Maximum Air Velocity: **5000 fpm (25 m/s)**.
 - 5. Temperature Range: **Minus 20 to plus 250 deg F (Minus 29 to plus 121 deg C)**.
 - 6. Insulation R-Value: **[Comply with ASHRAE/IES 90.1][R4.2][R6][R8]<Insert value>**.
 - 7. Vapor-Barrier Film: **[Polyethylene][Aluminized]**, ASTM E96/E96M.

2.22 FLEXIBLE DUCT CONNECTORS

- A. Clamps: **[Stainless steel band with stainless steel or zinc-plated hex screw to tighten band with a worm-gear action][Nylon strap]** in sizes **3 through 18 inches (75 through 460 mm)**, to suit duct size.
- B. Non-Clamp Connectors: **[Adhesive][Liquid adhesive plus tape][Adhesive plus sheet metal screws]**.

PART 3 - EXECUTION

3.1 INSTALLATION OF AIR DUCT ACCESSORIES

- A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.
- C. Install **[backdraft][control]** dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full-system-design static pressure.
- E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having a duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- F. Set dampers to fully open position before testing, adjusting, and balancing.
- G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.
- H. Install fire **[and smoke]** dampers in accordance with UL listing.
- I. Duct Security Bars:
 - 1. Construct duct security bars from **[0.164 inch (4.18 mm)]<Insert dimension>** steel sleeve, continuously welded at all joints, and **[1/2-inch- (13-mm)]<Insert dimension>** diameter steel bars, **[6 inches (150 mm)]<Insert dimension>** o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld **[2-1/2-by-2-1/2-by-1/4-inch (64-by-64-by-6-mm)]<Insert dimensions>** steel angle to four sides and both ends of sleeve.
 - 2. Connect duct security bars to ducts with flexible connections. Provide **12-by-12-inch (300-by-300-mm)** hinged access panel with cam lock in duct in each side of sleeve.
 - 3. Secure duct security bar assembly to building structure **[as detailed on Drawings][as indicated in manufacturer's written installation instructions]**.
- J. Connect ducts to duct silencers **[with flexible duct connectors][rigidly]**.
- K. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream **[and downstream]** from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links are to be pressure-relief access doors and be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 7. At each change in direction and at maximum **[50 ft. (15 m)]<Insert value>** spacing.
 - 8. Upstream **[and downstream]** from turning vanes.
 - 9. Upstream or downstream from duct silencers.
 - 10. For grease ducts, install at locations and spacing as required by NFPA 96.
 - 11. Control devices requiring inspection.

- 12. Elsewhere as indicated.
- L. Install access doors with swing against duct static pressure.
- M. Access Door Sizes:
 - 1. One-Hand or Inspection Access: **8 by 5 inches (200 by 125 mm)**.
 - 2. Two-Hand Access: **12 by 6 inches (300 by 150 mm)**.
 - 3. Head and Hand Access: **18 by 10 inches (460 by 250 mm)**.
 - 4. Head and Shoulders Access: **21 by 14 inches (530 by 355 mm)**.
 - 5. Body Access: **25 by 14 inches (635 by 355 mm)**.
 - 6. Body plus Ladder Access: **25 by 17 inches (635 by 430 mm)**.
- N. Label access doors in accordance with Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of each access door.
- O. Install flexible connectors to connect ducts to equipment.
- P. For fans developing static pressures of **5 inches wg (1250 Pa)** and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- Q. Install duct test holes where required for testing and balancing purposes.
- R. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of **1/4-inch (6-mm)** movement during start and stop of fans.
- S. Install flexible ducts in accordance with applicable details in the following publications:
 - 1. ADC's "Flexible Duct Performance & Installation Standards" for flexible ducts.
 - 2. NAIMA AH116.
 - 3. SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.
 - 4. SMACNA's "Fibrous Glass Duct Construction Standards" for fibrous-glass ducts.
- T. Install in indoor applications only. Do not install flexible duct in locations where it will be exposed to UV rays.
- U. Where flexible duct is to be installed in locations where it will be exposed to UV rays, install only duct that is specifically made for this use and is has been so marked by the manufacturer.
- V. Connect terminal units to supply ducts[**directly or**] with maximum [**12-inch (300-mm)**]**<Insert dimension>** lengths of flexible duct. Do not use flexible ducts to change directions.
- W. Connect diffusers and light troffer boots to ducts[**directly or**] with maximum [**60-inch (1500-mm)**]**<Insert dimension>** lengths of flexible duct clamped or strapped in place.
- X. Connect flexible ducts to metal ducts with [**adhesive**][**liquid adhesive plus tape**][**draw bands**][**adhesive plus sheet metal screws**].
- Y. Installation of Flexible Ducts:
 - 1. Install ducts fully extended.
 - 2. Do not bend ducts across sharp corners.
 - 3. Bends of flexible ducting must not exceed a minimum of one-duct diameter.
 - 4. Avoid contact with metal fixtures, water lines, pipes, or conduits.

5. Install flexible ducts in a direct line, without sags, twists, or turns.
6. Install in accordance with ADC instructions.

Z. Supporting Flexible Ducts:

1. Support flexible duct at manufacturer's recommended intervals, but at no greater distance than **4 ft. (1.2 m)**. Provide sufficient support so that maximum centerline sag is **1/2 inch per ft. (42 mm per meter)** between supports. A connection to rigid duct or equipment may be considered a support joint.
2. Install extra supports at bends placed approximately one-duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports must not exceed the maximum spacing in accordance with manufacturer's written installation instructions.
4. Vertically installed ducts must be stabilized by support straps at a maximum of **72 inches (1800 mm)** o.c.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 33 00 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 33 13 00	23 33 00 00	Air Duct Accessories
23 33 13 13	23 33 00 00	Air Duct Accessories
23 33 13 16	23 33 00 00	Air Duct Accessories
23 33 13 19	23 33 00 00	Air Duct Accessories
23 33 13 23	23 33 00 00	Air Duct Accessories
23 33 13 33	23 33 00 00	Air Duct Accessories
23 33 13 43	23 33 00 00	Air Duct Accessories
23 33 19 00	23 33 00 00	Air Duct Accessories
23 33 23 00	23 33 00 00	Air Duct Accessories
23 33 33 00	23 33 00 00	Air Duct Accessories
23 33 43 00	23 33 00 00	Air Duct Accessories
23 33 46 00	23 31 13 00	Metal Ducts
23 33 46 00	23 33 00 00	Air Duct Accessories
23 33 53 00	23 31 13 00	Metal Ducts
23 33 53 00	23 31 00 00	Shop-Fabricated HVAC Casings
23 33 53 00	23 33 00 00	Air Duct Accessories
23 33 56 00	23 31 13 00	Metal Ducts
23 33 56 00	23 33 00 00	Air Duct Accessories
23 33 59 00	23 33 00 00	Air Duct Accessories



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 34 00 00 - HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fans, tubeaxial.
2. Fans, vaneaxial.
3. Fans, mixed flow.
4. Fans, centrifugal - backward-inclined blades.
5. Fans, centrifugal - forward-curved blades.
6. Fans, centrifugal, inline - square.
7. Fans, centrifugal, inline - tubular.
8. Fans, plenum.
9. Fans, plug.
10. Fans, utility set.
11. Ventilators, axial - roof mounted.
12. Ventilators, centrifugal - ceiling mounted.
13. Ventilators, centrifugal - roof-mounted downblast.
14. Ventilators, centrifugal - roof-mounted upblast and sidewall mounted.
15. Fans, propeller - sidewall mounted.
16. Fans, propeller - roof-mounted upblast.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
 - b. Rated capacities, furnished specialties, and accessories for each fan.
 - c. Fans:
 - 1) Certified fan performance curves with system operating conditions indicated.
 - 2) Certified fan sound-power ratings.
 - 3) Fan construction and accessories.
 - 4) Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 5) Fan speed controllers.
 - d. Material thickness and finishes, including color charts.
 - e. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.



4. Design Calculations: Calculate requirements for selecting vibration isolators **[and seismic restraints]** and for designing vibration isolation bases.
 5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- C. Delegated Design Submittal: For vibration isolation[, **supports**,]**[and seismic restraints]** indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Design Calculations: Calculate requirements for selecting vibration isolators[, **supports**,]**[, seismic restraints,][and for designing vibration isolation bases]**.
- D. Sustainable Design Submittals:
1. Product data showing compliance with ASHRAE 62.1.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans showing fan rooms and fan system layouts, reflected ceiling plans, and other drawings required to illustrate relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
- B. Seismic Qualification Data: Certificates, for fans, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Startup service reports.
- D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fans and ventilators, include the following:
1. Operation in normal and emergency modes.
 2. Operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective coverage for storage and identified with labels describing contents.
1. Belts: **[One]<Insert number>** set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[, **supports**],[**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Seismic Performance: Fans and ventilators are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]**<Insert requirement>. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: **[1.5]**[1.0].
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- G. Capacities and Characteristics:
 - 1. Fan Type: **[Centrifugal]**[Square, inline, centrifugal][Tubular, inline, centrifugal][Plenum][Plug][Utility set].
 - 2. Blade Type: **[Forward curved]**[Backward inclined, airfoil][Backward inclined, curved][Backward inclined, flat].
 - 3. Airflow: **<Insert cfm (L/s)>**.
 - 4. Total Static Pressure: **<Insert inches wg (Pa)>**.
 - 5. Class: AMCA 99, Section 14, **[Class I]**[Class II][Class III].
 - 6. Drive Arrangement: **<Insert AMCA arrangement number>**.
 - 7. Drive Type: **[Belt]**[Direct].
 - 8. Discharge Arrangement: **<Insert discharge arrangement configuration>**.
 - 9. Housing Material: **[Reinforced steel]**[Shaped fiberglass-reinforced plastic][Aluminum][Stainless steel].
 - 10. Housing Coating: **[None]**[Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel]<Insert manufacturer's name and trade name>.
 - 11. Wheel Size (Diameter): **<Insert inches (mm)>**.
 - 12. Fan Diameter: **<Insert inches (mm)>**.
 - 13. Wheel Material: **[Steel]**[Aluminum][One-piece fiberglass-reinforced plastic][Stainless steel].
 - 14. Wheel Coating: **[None]**[Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel]; <Insert manufacturer's name and trade name>.
 - 15. Brake Horsepower: **<Insert number>**.
 - 16. Fan rpm: **<Insert value>**.
 - 17. Outlet Velocity: **<Insert fpm (m/s)>**.

18. Motor:

- a. Motor Enclosure: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion proof]<Insert motor enclosure type>**.
- b. Enclosure Materials: **[Cast iron][Cast aluminum][Rolled steel]**.
- c. Motor Bearings: **<Insert requirements>**.
- d. Efficiency: Premium efficiency.
- e. NEMA Design: **<Insert designation>**.
- f. Service Factor: **[1.15]<Insert number>**.
- g. Suitable for Use with Variable-Frequency Drive: **[Yes][No]**.
- h. Electrical Characteristics:
 - 1) Motor Size: **<Insert horsepower>**.
 - 2) Motor Rpm: **<Insert number>**.
 - 3) Volts: **[120][208][230][460]<Insert number> V**.
 - 4) Phase: **[Single][Three]**.
 - 5) Hertz: 60 Hz.
 - 6) Full-Load Amperes: **<Insert number> A**.
 - 7) Minimum Circuit Ampacity: **<Insert number> A**.
 - 8) Maximum Overcurrent Protection: **<Insert number> A**.

19. Discharge Sound Power:

- a. 1st Octave: **<Insert dB>**.
- b. 2nd Octave: **<Insert dB>**.
- c. 3rd Octave: **<Insert dB>**.
- d. 4th Octave: **<Insert dB>**.
- e. 5th Octave: **<Insert dB>**.
- f. 6th Octave: **<Insert dB>**.
- g. 7th Octave: **<Insert dB>**.
- h. 8th Octave: **<Insert dB>**.

20. Inlet Sound Power:

- a. 1st Octave: **<Insert dB>**.
- b. 2nd Octave: **<Insert dB>**.
- c. 3rd Octave: **<Insert dB>**.
- d. 4th Octave: **<Insert dB>**.
- e. 5th Octave: **<Insert dB>**.
- f. 6th Octave: **<Insert dB>**.
- g. 7th Octave: **<Insert dB>**.
- h. 8th Octave: **<Insert dB>**.

- 21. Vibration Isolators: **[Spring][Restrained spring]<Insert type>** isolators with a static deflection of **[1 inch (25 mm)]<Insert deflection>**.
- 22. Spark-Resistance Class: Classified in accordance with AMCA 99, Section 8, **[Type A][Type B][Type C]**.

H. Service Conditions:

- 1. Ambient Temperature: **<Insert number> deg F (deg C)**.
- 2. Altitude: **<Insert number> feet (m)** above sea level.
- 3. Humidity: **<Insert number> deg F (deg C)** wet bulb.

2.2 FANS, TUBEAXIAL

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Acme Engineering & Manufacturing Corp.]**
 2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 3. **[Airmaster Fan; a brand of MAICO]**
 4. **[American Coolair Corporation]**
 5. **[Carnes Company]**
 6. **[Chicago Blower Corporation]**
 7. **[Cincinnati Fan]**
 8. **[Greenheck Fan Corporation]**
 9. **[Hartzell Fan Incorporated]**
 10. **[Howden American Fan Company]**
 11. **[Loren Cook Company]**
 12. **[New York Blower Company (The)]**
 13. **[Northern Blower, Inc.]**
 14. **[PennBarry; division of Air System Components]**
 15. **[S & P Products]**
 16. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Acme Engineering & Manufacturing Corp.]**
 2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 3. **[Airmaster Fan; a brand of MAICO]**
 4. **[American Coolair Corporation]**
 5. **[Carnes Company]**
 6. **[Chicago Blower Corporation]**
 7. **[Cincinnati Fan]**
 8. **[Greenheck Fan Corporation]**
 9. **[Hartzell Fan Incorporated]**
 10. **[Howden American Fan Company]**
 11. **[Loren Cook Company]**
 12. **[New York Blower Company (The)]**
 13. **[Northern Blower, Inc.]**
 14. **[PennBarry; division of Air System Components]**
 15. **[S & P Products]**
 16. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain tubeaxial fans from single manufacturer.
- D. Standards: Comply with UL 705.
- E. Description: Fan wheel and housing, factory-mounted motor with **[belt][or][direct]** drive, an inlet cone section, and accessories.
- F. Housings: **[Steel][Galvanized steel][Aluminum][Fiberglass-reinforced plastic][Stainless steel]** with flanged inlet and outlet connections.
- G. Wheel Assemblies: **[Cast or extruded aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key][Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless steel shaft][Cast aluminum; machined and**

fitted to shaft].

H. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: **[1.2][1.3][1.4][1.5]**.
3. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
4. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through **[5]<Insert number>** hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
8. Motor Base: Adjustable rail mount motor base with adjustment screw to set belt tension.
9. Shaft Bearings: Radial, self-aligning bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, **[L10 of 50,000 hours]<Insert life>**.
 - b. Roller-Bearing Rating Life: ABMA 11, **[L10 of 50,000 hours]<Insert life>**.
 - c. Extend lubrication lines to outside of casing and terminate with grease fittings.

I. Accessories:

1. Companion Flanges: Rolled flanges of same material as housing.
2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
3. Propeller Access Section Door: Short duct section bolted to fan **[inlet][and][outlet]** allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
4. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
5. Mounting Clips: **[Horizontal ceiling][Vertical mounting]** clips welded to fan housing, of same material as housing.
6. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
7. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
8. Inlet Screen: On unducted fan inlet - wire-mesh screen, of same material as housing.
9. Outlet Screen: On unducted fan outlet - wire-mesh screen, of same material as housing.
10. Backdraft Dampers: Butterfly style, for bolting to fan discharge or outlet cone, of same material as housing.
11. Shaft Seal: Elastomeric seal and PTFE wear plate, suitable for up to **300 deg F (149 deg C)**.
12. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
13. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation, of same material as housing.
14. Inlet Bell: Curved inlet for when fan is not attached to duct, **[of same material as housing]; aluminum]**.
15. Inlet Cone: Round-to-round transition, of same material as housing.
16. Outlet Cone: Round-to-round transition, of same material as housing.
17. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
18. Direct-Driven Units: Encase motor in housing outside of airstream. Extend lubrication lines to outside of casing and terminate with grease fittings.
19. **[Factory-wired motor disconnect switch located on outside of fan housing.]**

J. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: **[Epoxy][Zinc][Phenolic][Powder-baked enamel]**; **<Insert manufacturer's name and trade name>**.
 - a. Apply to finished housings.
 - b. Apply to fan wheels.

2.3 FANS, VANEAXIAL

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Acme Engineering & Manufacturing Corp.]**
2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
3. **[American Coolair Corporation]**
4. **[Chicago Blower Corporation]**
5. **[Greenheck Fan Corporation]**
6. **[Hartzell Fan Incorporated]**
7. **[Howden American Fan Company]**
8. **[Loren Cook Company]**
9. **[New York Blower Company (The)]**
10. **[Northern Blower, Inc.]**
11. **[PennBarry; division of Air System Components]**
12. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Acme Engineering & Manufacturing Corp.]**
2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
3. **[American Coolair Corporation]**
4. **[Chicago Blower Corporation]**
5. **[Greenheck Fan Corporation]**
6. **[Hartzell Fan Incorporated]**
7. **[Howden American Fan Company]**
8. **[Loren Cook Company]**
9. **[New York Blower Company (The)]**
10. **[Northern Blower, Inc.]**
11. **[PennBarry; division of Air System Components]**
12. **<Insert manufacturer's name>**

C. Source Limitations: Obtain vaneaxial fans from single manufacturer.

D. Standards: Comply with UL 705.

E. Description: Fan wheel and housing, straightening vane section, factory-mounted motor with belt or direct drive, an inlet cone section, and accessories.

1. Variable-Pitch Fans: Internally mounted **[electric][electronic]** actuator, externally mounted positive positioner, and mechanical-blade-pitch indicator.



- F. Housings: **[Steel][Aluminum][Fiberglass-reinforced plastic][Stainless steel]<Insert material>**.
1. Inlet and Outlet Connections: Flanges.
 2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
- G. Wheel Assemblies: **[Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key][Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless steel shaft][Cast-aluminum hub assembly, machined and fitted with threaded bearing wells to receive blade-bearing assemblies with replaceable, cast-aluminum blades; factory mounted and balanced]**.
- H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
1. Service Factor Based on Fan Motor Size: **[1.2][1.3][1.4][1.5]**.
 2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
 3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
 4. Motor Pulleys: Adjustable pitch for use with motors through **[5]<Insert number>** hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 6. Belt Guards: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 7. Motor Base: Adjustable rail mount motor base with adjustment screw to set belt tension.
 8. Shaft Bearings: Radial, self-aligning bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, **[L10 of 100,000 hours]<Insert life>**.
 - b. Roller-Bearing Rating Life: ABMA 11, **[L10 of 100,000 hours]<Insert life>**.
 - c. Extend lubrication lines to outside of casing and terminate with grease fittings.
- I. Accessories:
1. Companion Flanges: Rolled flanges of same material as housing.
 2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
 3. Propeller Access Section Door: Short duct section bolted to fan **[inlet][and][outlet]** allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
 4. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
 5. Mounting Clips: **[Horizontal ceiling][Vertical mounting]** clips welded to fan housing, of same material as housing.
 6. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
 7. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
 8. Inlet Screen: On unducted fan inlet - wire-mesh screen, of same material as housing.
 9. Outlet Screen: On unducted fan outlet - wire-mesh screen, of same material as housing.
 10. Backdraft Dampers: Butterfly style, for mounting with flexible connection to fan discharge or direct mounted to discharge diffuser section, of same material as housing.
 11. Stall Alarm Probe: Sensing probe capable of detecting fan operation in stall and signaling control devices. Control devices and sequence of operation are specified in Section 230923.23 "Pressure Instruments" and Section 230993.11 "Sequence of Operations for HVAC DDC."
 12. Flow Measurement Port: Pressure measurement taps installed in fan inlet to detect and signal airflow readings to temperature-control systems. Control devices and sequence of operation are

specified in Section 230923.14 "Flow Instruments" and Section 230993.11 "Sequence of Operations for HVAC DDC."

13. Shaft Seal: Elastomeric seal and PTFE wear plate, suitable for up to **300 deg F (148 deg C)**.
14. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
15. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
16. Inlet Cone: Round-to-round transition, of same material as housing.
17. Outlet Cone: Round-to-round transition, of same material as housing.
18. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
19. Direct-Driven Units: Encase motor in housing outside of airstream. Extend lubrication lines to outside of casing and terminate with grease fittings.
20. **[Factory-wired motor disconnect switch located on outside of fan housing.]**

J. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: **[Epoxy][Zinc][Phenolic][Powder-baked enamel]; <Insert manufacturer's name and trade name>**.
 - a. Apply to finished housings.
 - b. Apply to fan wheels.

2.4 FANS, MIXED FLOW

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Acme Engineering & Manufacturing Corp.]**
2. **[Greenheck Fan Corporation]**
3. **[Howden American Fan Company]**
4. **[Loren Cook Company]**
5. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Acme Engineering & Manufacturing Corp.]**
2. **[Greenheck Fan Corporation]**
3. **[Howden American Fan Company]**
4. **[Loren Cook Company]**
5. **<Insert manufacturer's name>**

C. Source Limitations: Obtain mixed-flow fans from single manufacturer.

D. Standards: Comply with UL 705.

E. Description: Fan wheel and housing, **[straightening vane section,]** factory-mounted motor with **[belt drive][or][direct drive]**, and accessories.

F. Housings: **[Steel][Galvanized steel][Aluminum]**.

1. Inlet and Outlet Connections: Outer mounting frame and companion flanges.
2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.



3. Mixed-Flow Outlet Connection: **[One][Two]** flanged discharge(s) perpendicular to fan inlet.

G. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: **[1.2][1.3][1.4][1.5]**.
2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through **[5]<Insert number>** hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Motor Base: Adjustable rail mount motor base with adjustment screw to set belt tension.
7. Shaft Bearings: Radial, self-aligning bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, **[L10 of 100,000 hours]<Insert life>**.
 - b. Roller-Bearing Rating Life: ABMA 11, **[L10 of 100,000 hours]<Insert life>**.
 - c. Extend lubrication lines to outside of casing and terminate with grease fittings.

I. Accessories:

1. Mounting Clips: **[Horizontal ceiling][Vertical mounting]** clips welded to fan housing, of same material as housing.
2. Inlet and Outlet Screens: On unducted fan inlet and outlet - wire-mesh screen, of same material as housing.
3. Backdraft Dampers: Butterfly style, for mounting with flexible connection to fan discharge or direct mounted to discharge diffuser section, of same material as housing.
4. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
5. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
6. Inlet Cones: Round-to-round transition, of same material as housing.
7. Outlet Cones: Round-to-round transition, of same material as housing.
8. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
9. Belt Guard: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
10. Direct-Driven Units: Encase motor in housing outside of airstream.
11. **[Factory-wired motor disconnect switch located on outside of fan housing.]**

J. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: **[Epoxy][Zinc][Phenolic][Powder-baked enamel]; <Insert manufacturer's name and trade name>**.
 - a. Apply to finished housings.
 - b. Apply to fan wheels.

2.5 FANS, CENTRIFUGAL - BACKWARD-INCLINED BLADES

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide**

products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Canarm Ltd.]
4. [Central Blower Company]
5. [Chicago Blower Corporation]
6. [Cincinnati Fan]
7. [COMEFRI]
8. [Loren Cook Company]
9. [New York Blower Company (The)]
10. [Northern Blower, Inc.]
11. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Canarm Ltd.]
4. [Central Blower Company]
5. [Chicago Blower Corporation]
6. [Cincinnati Fan]
7. [COMEFRI]
8. [Loren Cook Company]
9. [New York Blower Company (The)]
10. [Northern Blower, Inc.]
11. <Insert manufacturer's name>

C. Source Limitations: Obtain backward-inclined centrifugal fans from single manufacturer.

D. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, [~~belt-~~][~~direct-~~]driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
2. Factory-installed and -wired disconnect switch.

E. Standards: Comply with UL 705.

F. Housings:

1. Housing Material: [Reinforced steel][Shaped fiberglass-reinforced plastic][Aluminum][Stainless steel][See schedule]<Insert material>.
2. Housing Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.
3. Housing Assembly: Sideplates[continuously welded][or][spot welded][or][attached by continuous Pittsburgh lock seal or similar seal].
4. Formed panels to make curved-scroll housings with shaped cutoff.
5. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
6. Horizontally split, bolted-flange housing.
7. Spun inlet cone with flange.
8. Outlet flange.

9. Discharge Arrangement: Fan scroll housing is field rotatable to any of **[seven][eight]** discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns.

G. Wheels:

1. Wheel Configuration: **[SWSI][DWDI]** construction with a precision-spun curved inlet flange and a backplate fastened to shaft with setscrews. Wheels are to be statically and dynamically balanced, and nonoverloading.
2. Wheel and Blade Material: **[Steel][Aluminum][One-piece fiberglass-reinforced plastic][Stainless steel][See schedule]**.
3. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8, **[Type A][Type B][Type C]**.
4. Wheel and Blade Coating: **[None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>**.
5. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
6. Backward-Inclined Airfoil Blades:
 - a. Aerodynamic design.
 - b. Heavy backplate.
 - c. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
7. Backward-Inclined Curved Blades:
 - a. Curved design.
 - b. Heavy backplate.
 - c. Single-thickness blades continuously welded at tip flange and backplate.

H. Shafts:

1. Statically and dynamically balanced, and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

I. Bearings:

1. Prelubricated and Sealed Shaft Bearings:
 - a. Self-aligning, pillow-block-type ball bearings.
 - b. Ball-Bearing Rating Life: ABMA 9, L10 at **[50,000][120,000]<Insert number>** hours.
 - c. Roller-Bearing Rating Life: ABMA 11, L10 at **[50,000][120,000]<Insert number>** hours.
2. Grease-Lubricated Shaft Bearings, Tapered Roller:
 - a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at **[50,000][120,000]<Insert number>** hours.
 - c. Extended Lubrication Lines: Extend lines to accessible location.
3. Grease-Lubricated Shaft Bearings, Ball or Roller:
 - a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece,

- cast-iron housing.
- b. Ball-Bearing Rating Life: ABMA 9, L10 at [50,000][120,000]<Insert number> hours.
- c. Roller-Bearing Rating Life: ABMA 11, L10 at [50,000][120,000]<Insert number> hours.
- d. Extended Lubrication Lines: Extend lines to accessible location.

J. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: [1.5][1.4][1.3][1.2].
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through [5]<Insert number> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch pulleys for use with motors larger than [5]<Insert number> hp.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; [0.146-inch- (2.7-mm-)]<Insert dimension> thick, [3/4-inch (20-mm)]<Insert dimension> diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

K. Motor Enclosure: [Open, dripproof][Totally enclosed, fan cooled][Explosion proof][Totally enclosed, air over]<Insert motor enclosure type>.

L. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: **NPS 1 (DN 25)** steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Discharge Dampers: Assembly with [parallel][opposed] blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
8. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
9. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.6 FANS, CENTRIFUGAL - FORWARD-CURVED BLADES

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Acme Engineering & Manufacturing Corp.]
2. [Canarm Ltd.]
3. [Central Blower Company]
4. [Lau Fan]
5. [New York Blower Company (The)]
6. [Plastec Ventilation Inc.]
7. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:



1. [Acme Engineering & Manufacturing Corp.]
2. [Canarm Ltd.]
3. [Central Blower Company]
4. [Lau Fan]
5. [New York Blower Company (The)]
6. [Plastec Ventilation Inc.]
7. <Insert manufacturer's name>

C. Source Limitations: Obtain forward-curved blade centrifugal fans from single manufacturer.

D. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, [belt-][direct-]driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

E. Standards: Comply with UL 705.

F. Housings:

1. Housing Material: [Reinforced steel][Shaped fiberglass-reinforced plastic][Aluminum][Stainless steel][See schedule].
2. Housing Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.
3. Housing Assembly: Sideplates [continuously welded][or][spot welded][or][attached by continuous Pittsburgh lock seal or similar seal].
4. Formed panels to make curved-scroll housings with shaped cutoff.
5. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
6. Horizontally split, bolted-flange housing.
7. Spun inlet cone with flange.
8. Outlet flange.
9. Discharge Arrangement: Fan scroll housing field rotatable to any of [seven][eight] discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns.

G. Wheels:

1. Wheel Configuration: [SWSI][DWDI] construction with a curved inlet flange and a backplate fastened to shaft with setscrews.
2. Wheel and Blade Material: [Steel][Aluminum][One-piece fiberglass-reinforced plastic][Stainless steel][See schedule].
 - a. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8, [Type A][Type B][Type C].
3. Wheel and Blade Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with setscrews.
5. Forward-Curved Wheels:
 - a. Black-enameled or galvanized-steel construction with inlet flange, backplate, and shallow

- blades with inlet and tip curved forward in direction of airflow.
- b. Mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with setscrews.

H. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

I. Bearings:

1. Prelubricated and Sealed Shaft Bearings:
 - a. Self-aligning, pillow-block-type **[ball][roller]** bearings.
 - b. Ball-Bearing Rating Life: ABMA 9, L10 at **[50,000][120,000]<Insert number>** hours.
 - c. Roller-Bearing Rating Life: ABMA 11, L10 at **[50,000][120,000]<Insert number>** hours.
2. Grease-Lubricated Shaft Bearings, Tapered Roller:
 - a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at **[50,000][120,000]<Insert number>** hours.
 - c. Extended Lubrication Lines: Extend lines to accessible location.
3. Grease-Lubricated Shaft Bearings, Ball or Roller:
 - a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
 - b. Ball-Bearing Rating Life: ABMA 9, L10 at **[50,000][120,000]<Insert number>** hours.
 - c. Roller-Bearing Rating Life: ABMA 11, L10 at **[50,000][120,000]<Insert number>** hours.
 - d. Extended Lubrication Lines: Extend lines to accessible location.

J. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: **[1.5][1.4][1.3][1.2]**.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through **[5]<Insert number>** hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than **[5]<Insert number>** hp.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; **[0.146-inch- (2.7-mm-)]<Insert dimension>** thick, **[3/4-inch (20-mm)]<Insert dimension>** diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

K. Motor Enclosure: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion proof]**.

L. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: **NPS 1 (DN 25)** steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Discharge Dampers: Assembly with **[parallel][opposed]** blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
8. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
9. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.7 FANS, CENTRIFUGAL, INLINE - SQUARE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Acme Engineering & Manufacturing Corp.]**
2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
3. **[American Coolair Corporation]**
4. **[Canarm Ltd.]**
5. **[Carnes Company]**
6. **[FloAire National]**
7. **[Greenheck Fan Corporation]**
8. **[JencoFan]**
9. **[Loren Cook Company]**
10. **[PennBarry; division of Air System Components]**
11. **[Quietaire Inc.]**
12. **[Rupp Air Management Systems]**
13. **[S & P USA Ventilation Systems, LLC]**
14. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Acme Engineering & Manufacturing Corp.]**
2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
3. **[American Coolair Corporation]**
4. **[Canarm Ltd.]**
5. **[Carnes Company]**
6. **[FloAire National]**
7. **[Greenheck Fan Corporation]**
8. **[JencoFan]**
9. **[Loren Cook Company]**
10. **[PennBarry; division of Air System Components]**
11. **[Quietaire Inc.]**
12. **[Rupp Air Management Systems]**
13. **[S & P USA Ventilation Systems, LLC]**
14. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain square inline centrifugal fans from single manufacturer.

- D. Description: Square-housing in-line centrifugal fans.

- E. Standards: Comply with UL 705.
- F. Housing:
 - 1. Housing Material: **[Reinforced steel][Aluminum][Stainless steel][See schedule]<Insert material>**.
 - 2. Housing Coating: **[None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>**.
 - 3. Housing Construction: Side panels are to be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- G. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; **with wheel, inlet cone, and motor on swing-out service door**.
- H. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosures around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- I. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.
- J. Motor Enclosure: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion-proof]<Insert motor enclosure type>**.
- K. Accessories:
 - 1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
 - 2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 - 4. Companion Flanges: For inlet and outlet duct connections.
 - 5. Fan Guards: **1/2- by 1-inch (13- by 25-mm)** mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 - 6. Motor: Epoxy-coated steel.
 - 7. Belt Guards: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - 8. Side Discharge: Flange connector and attachment hardware to provide right-angle discharge on side of unit.

2.8 FANS, CENTRIFUGAL, INLINE - TUBULAR

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Acme Engineering & Manufacturing Corp.]**
 - 2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 - 3. **[American Coolair Corporation]**
 - 4. **[Hartzell Fan Incorporated]**
 - 5. **[JencoFan]**
 - 6. **[Loren Cook Company]**
 - 7. **[New York Blower Company (The)]**
 - 8. **[Peerless Blowers]**
 - 9. **[PennBarry; division of Air System Components]**
 - 10. **[S & P USA Ventilation Systems, LLC]**
 - 11. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Acme Engineering & Manufacturing Corp.]**
 2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 3. **[American Coolair Corporation]**
 4. **[Hartzell Fan Incorporated]**
 5. **[JencoFan]**
 6. **[Loren Cook Company]**
 7. **[New York Blower Company (The)]**
 8. **[Peerless Blowers]**
 9. **[PennBarry; division of Air System Components]**
 10. **[S & P USA Ventilation Systems, LLC]**
 11. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain tubular in-line centrifugal fans from single manufacturer.
- D. Description: Tubular-housing in-line centrifugal fans.
- E. Housing:
1. Housing Material: **[Reinforced steel][Shaped fiberglass-reinforced plastic][Aluminum][Stainless steel][See schedule]<Insert material>**.
 2. Housing Coating: **[None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>**.
 3. Housing Construction: Split, **[spun aluminum]**with **[aluminum]**straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- F. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; **with wheel, inlet cone, and motor on swing-out service door**.
- G. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- H. Fan Wheels: **[Steel][Aluminum]**, airfoil blades welded to aluminum hub.
- I. Motor Enclosure: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion proof]<Insert motor enclosure type>**.
- J. Accessories:
1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
 2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 4. Companion Flanges: For inlet and outlet duct connections.
 5. Fan Guards: **1/2- by 1-inch (13- by 25-mm)** mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 6. Motor Cover: Epoxy-coated steel.
 7. Belt Guard: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

2.9 FANS, PLENUM

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 2. **[Chicago Blower Corporation]**
 3. **[Cincinnati Fan]**
 4. **[COMEFRI]**
 5. **[Loren Cook Company]**
 6. **[New York Blower Company (The)]**
 7. **[Northern Blower, Inc.]**
 8. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 2. **[Chicago Blower Corporation]**
 3. **[Cincinnati Fan]**
 4. **[COMEFRI]**
 5. **[Loren Cook Company]**
 6. **[New York Blower Company (The)]**
 7. **[Northern Blower, Inc.]**
 8. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain plenum fans from single manufacturer.
- D. Description:
1. Factory-fabricated, -assembled, -tested, and -finished, **[belt-][direct-]**driven centrifugal fans, consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.
 2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
 3. **[Factory-installed and -wired disconnect switch.]**
- E. Standards: Comply with UL 705.
- F. Wheels:
1. Wheel Configuration: SWSI construction with curved inlet flange and heavy backplate; fastened to shaft with setscrews.
 2. Wheel and Blade Material: **[Steel][Aluminum][One-piece fiberglass-reinforced plastic][Stainless steel][See schedule]**.
 - a. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8, **[Type A][Type B][Type C]**.
 3. Wheel and Blade Coating: **[None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>**.
 4. Backward-Inclined Airfoil Blades: Hollow, die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
- G. Shafts:

1. Statically and dynamically balanced, and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

H. Bearings:

1. Prelubricated and Sealed Shaft Bearings:
 - a. Self-aligning, pillow-block-type ball bearings.
 - b. Ball-Bearing Rating Life: ABMA 9, L10 at **[50,000][120,000]<Insert number>** hours.
 - c. Roller-Bearing Rating Life: ABMA 11, L10 at **[50,000][120,000]<Insert number>** hours.
2. Grease-Lubricated Shaft Bearings, Tapered Roller:
 - a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at **[50,000][120,000]<Insert number>** hours.
 - c. Extended Lubrication Lines: Extend lines to accessible location.
3. Grease-Lubricated Shaft Bearings, Ball or Roller:
 - a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
 - b. Ball-Bearing Rating Life: ABMA 9, L10 at **[50,000][120,000]<Insert number>** hours.
 - c. Roller-Bearing Rating Life: ABMA 11, L10 at **[50,000][120,000]<Insert number>** hours.
 - d. Extended Lubrication Lines: Extend lines to accessible location.

I. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: **[1.5][1.4][1.3][1.2]**.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through **[5]<Insert number>** hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than **[5]<Insert number>** hp.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; **[0.146-inch- (2.7-mm-)]<Insert dimension>** thick, **[3/4-inch (20-mm)]** diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

J. Motor Enclosure: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion proof]**.

K. Accessories:

1. Inlet Safety Screen: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
2. Safety Enclosure: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle

- frame or equivalent, prime coated.
3. Belt Guard: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
4. Inlet Companion Flange: Rolled flanges for duct connections of same material as housing.
5. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
6. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
7. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.10 FANS, PLUG

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 2. **[Chicago Blower Corporation]**
 3. **[Cincinnati Fan]**
 4. **[Loren Cook Company]**
 5. **[New York Blower Company (The)]**
 6. **[Northern Blower, Inc.]**
 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 2. **[Chicago Blower Corporation]**
 3. **[Cincinnati Fan]**
 4. **[Loren Cook Company]**
 5. **[New York Blower Company (The)]**
 6. **[Northern Blower, Inc.]**
 7. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain plug fans from single manufacturer.
- D. Description:
1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans, consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.
 2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
 3. Factory-installed and -wired disconnect switch.
- E. Standards: Comply with UL 705.
- F. Wheels:
1. Wheel Configuration: SWSI construction with curved inlet flange and heavy backplate; fastened to shaft with setscrews.
 2. Wheel and Blade Material: **[Steel][Aluminum][One-piece fiberglass-reinforced plastic][Stainless steel][See schedule]**.
 - a. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8 **[Type A][Type B][Type C]**.

3. Wheel and Blade Coating: **[None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>**.
4. Backward-Inclined Airfoil Blades: Hollow, die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.

G. Shafts:

1. Statically and dynamically balanced, and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

H. Bearings:

1. Prelubricated and Sealed Shaft Bearings:
 - a. Self-aligning, pillow-block-type ball bearings.
 - b. Ball-Bearing Rating Life: ABMA 9, L10 at **[50,000][120,000]<Insert number>** hours.
 - c. Roller-Bearing Rating Life: ABMA 11, L10 at **[50,000][120,000]<Insert number>** hours.
2. Grease-Lubricated Shaft Bearings, Tapered Roller:
 - a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
 - b. Ball-Bearing Rating Life: ABMA 9, L10 at **[50,000][120,000]<Insert number>** hours.
 - c. Roller-Bearing Rating Life: ABMA 11, L10 at **[50,000][120,000]<Insert number>** hours.
 - d. Extended Lubrication Lines: Extend lines to accessible location.
3. Grease-Lubricated Shaft Bearings, Ball or Roller:
 - a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
 - b. Ball-Bearing Rating Life: ABMA 9, L10 at **[50,000][120,000]<Insert number>** hours.
 - c. Roller-Bearing Rating Life: ABMA 11, L10 at **[50,000][120,000]<Insert number>** hours.
 - d. Extended Lubrication Lines: Extend lines to accessible location.

I. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: **[1.5][1.4][1.3][1.2]**.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through **[5]<Insert number>** hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with larger motors.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; **[0.146-inch- (2.7-mm-)]<Insert dimension>** thick, **[3/4-inch (20-mm)]<Insert dimension>** diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

- J. Motor Enclosure: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion proof]**.
- K. Accessories:
1. Inlet Safety Screen: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
 2. Safety Enclosure: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
 3. Belt Guard: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
 4. Inlet Companion Flange: Rolled flanges for duct connections of same material as housing.
 5. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
 6. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

2.11 FANS, UTILITY SET

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 2. **[American Coolair Corporation]**
 3. **[Canarm Ltd.]**
 4. **[Carnes Company]**
 5. **[Delhi Industries Inc]**
 6. **[JencoFan]**
 7. **[Loren Cook Company]**
 8. **[New York Blower Company (The)]**
 9. **[Peerless Blowers]**
 10. **[PennBarry; division of Air System Components]**
 11. **[Quietaire Inc.]**
 12. **[Rupp Air Management Systems]**
 13. **[S & P USA Ventilation Systems, LLC]**
 14. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 2. **[American Coolair Corporation]**
 3. **[Canarm Ltd.]**
 4. **[Carnes Company]**
 5. **[Delhi Industries Inc]**
 6. **[JencoFan]**
 7. **[Loren Cook Company]**
 8. **[New York Blower Company (The)]**
 9. **[Peerless Blowers]**
 10. **[PennBarry; division of Air System Components]**
 11. **[Quietaire Inc.]**
 12. **[Rupp Air Management Systems]**
 13. **[S & P USA Ventilation Systems, LLC]**

14. <Insert manufacturer's name>

C. Source Limitations: Obtain fan utility sets from single manufacturers.

D. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, [~~belt-~~][~~direct-~~]driven centrifugal fan utility vent sets, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

E. Standards: Comply with UL 705.

F. Housings:

1. Housing Material: [**Reinforced steel**][**Shaped fiberglass-reinforced plastic**][**Aluminum**][**Stainless steel**][**See schedule**]<Insert material>.
2. Housing Coating: [**None**][**Thermoplastic vinyl**][**Epoxy**][**Synthetic resin**][**Phenolic**][**Hot-dip galvanized**][**Powder-baked enamel**][**See schedule**]<Insert manufacturer's name and trade name>.
3. Formed panels to make curved-scroll housings with shaped cutoff.
4. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
5. Discharge Arrangement: Fan scroll housing field rotatable to any of [**seven**][**eight**] discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns.

G. Wheels:

1. Wheel Configuration: SWSI, with hub keyed to shaft.
2. Wheel and Blade Materials: [**Steel**][**Aluminum**][**One-piece fiberglass-reinforced plastic**][**Stainless steel**][**See schedule**].
 - a. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8 [**Type A**][**Type B**][**Type C**].
3. Wheel and Blade Coating: [**None**][**Thermoplastic vinyl**][**Epoxy**][**Synthetic resin**][**Phenolic**][**Hot-dip galvanized**][**Powder-baked enamel**][**See schedule**]<Insert manufacturer's name and trade name>.
4. Backward-Inclined Airfoil Blades:
 - a. Aerodynamic design.
 - b. Heavy backplate.
 - c. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
5. Backward-Inclined Curved Blades:
 - a. Curved design.
 - b. Heavy backplate.
 - c. Single-thickness blades continuously welded at tip flange and backplate.
6. Backward-Inclined Flat Blades:
 - a. Flat design.
 - b. Heavy backplate.
 - c. Single-thickness blades continuously welded at tip flange and backplate.

7. Forward-Curved Blades:
 - a. Curved design.
 - b. Heavy backplate.
 - c. Single-thickness blades continuously welded or riveted at tip flange and backplate.
- H. Shafts:
 1. Turned, ground, and polished steel; keyed to wheel hub. First critical speed at least 1.4 times maximum class speed.
- I. Bearings:
 1. Heavy-duty regreasable ball or roller type in a cast-iron pillowblock housing.
 2. Ball-Bearing Rating Life: ABMA 9, [L50 of 200,000 hours][L10 of 80,000 hours]<Insert life>.
 3. Roller-Bearing Rating Life: ABMA 11, [L50 of 200,000 hours][L10 of 80,000 hours]<Insert life>.
 4. Extend grease fitting to accessible location outside of unit.
- J. Belt Drive:
 1. Factory mounted, with final alignment and belt adjustment made after installation.
 2. Service Factor Based on Fan Motor Size: [1.5][1.4][1.3][1.2].
 3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 4. Motor Pulleys: Adjustable pitch for use with motors through [5]<Insert value> hp; fixed pitch for use with motors larger than [5]<Insert number> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 6. Belt Guards: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," [0.146-inch- (2.7-mm-)]<Insert dimension> thick, [3/4-inch (20-mm)]<Insert dimension> diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
- K. Motor Enclosure: [Open, dripproof][Totally enclosed, fan cooled][Explosion proof]<Insert motor enclosure type>.
- L. Accessories:
 1. Inlet and Outlet: Flanged.
 2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
 3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades, with felt edges in steel frame installed on fan discharge.
 4. Access Door: Gasketed door in scroll with latch-type handles.
 5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
 6. Inlet Screens: Removable wire mesh.
 7. Outlet Screens: Removable wire mesh.
 8. Belt Guard: OSHA-compliant, fabricated in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen welded to steel angle frame or equivalent, prime coated.
 9. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
 10. Drain Connections: NPS 3/4 (DN 20) threaded coupling drain connection installed at lowest point of housing.
 11. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
 12. Discharge Dampers: Assembly with [parallel][opposed] blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings, with blades linked outside of

airstream to single control lever of same material as housing.

13. Grease Collection Trough and Receiver: For restaurant exhaust application.
14. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

2.12 VENTILATORS, AXIAL - ROOF MOUNTED

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Acme Engineering & Manufacturing Corp.]**
2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
3. **[Airmaster Fan; a brand of MAICO]**
4. **[American Coolair Corporation]**
5. **[Broan.; a Broan-NuTone LLC brand; a Nortek company]**
6. **[FloAire National]**
7. **[Greenheck Fan Corporation]**
8. **[Hartzell Fan Incorporated]**
9. **[JencoFan]**
10. **[Loren Cook Company]**
11. **[Moffitt Corporation]**
12. **[New York Blower Company (The)]**
13. **[PennBarry; division of Air System Components]**
14. **[Quietaire Inc.]**
15. **[Rupp Air Management Systems]**
16. **[S & P USA Ventilation Systems, LLC]**
17. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Acme Engineering & Manufacturing Corp.]**
2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
3. **[Airmaster Fan; a brand of MAICO]**
4. **[American Coolair Corporation]**
5. **[Broan.; a Broan-NuTone LLC brand; a Nortek company]**
6. **[FloAire National]**
7. **[Greenheck Fan Corporation]**
8. **[Hartzell Fan Incorporated]**
9. **[JencoFan]**
10. **[Loren Cook Company]**
11. **[Moffitt Corporation]**
12. **[New York Blower Company (The)]**
13. **[PennBarry; division of Air System Components]**
14. **[Quietaire Inc.]**
15. **[Rupp Air Management Systems]**
16. **[S & P USA Ventilation Systems, LLC]**
17. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain roof-mounted axial ventilators from single manufacturer.
- D. Standards: Comply with UL 705.
- E. Housing: Heavy-gauge, removable, spun-aluminum dome top and outlet baffle; square, one-piece,

hinged, aluminum base.

- F. Fan Wheel: **[Aluminum][Steel]** hub and blades. **[Spark-resistant construction classified in accordance with AMCA 99, Section 8,][Type A][Type B][Type C]**.
- G. Belt Drives:
 - 1. Resiliently mounted to housing.
 - 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - 5. Motor Pulleys: Adjustable pitch for use with motors through **[5]<Insert number>** hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than **[5]<Insert number>** hp.
- H. Accessories:
 - 1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted **[inside][outside]** fan housing, factory wired through an internal aluminum conduit.
 - 2. Bird Screens: Removable, **1/2-inch (13-mm)** mesh, aluminum or brass wire.
 - 3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
 - 4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
 - 5. Stack hood with built-in backdraft dampers.
 - 6. Extended lubrication lines.
- I. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; **1-1/2-inch- (40-mm-)** thick, rigid, fiberglass insulation adhered to inside walls; and **1-1/2-inch (40-mm)** wood nailer. Size as required to suit roof opening and fan base.
 - 1. Configuration: **[Self-flashing without a cant strip, with mounting flange][Built-in cant and mounting flange][Built-in raised cant and mounting flange]**.
 - 2. Overall Height: **[8 inches (203 mm)][9-1/2 inches (240 mm)][12 inches (305 mm)][16 inches (400 mm)][18 inches (450 mm)]**.
 - 3. Sound Curb: Curb with sound-absorbing insulation.
 - 4. Pitch Mounting: Manufacture curb for roof slope.
 - 5. Metal Liner: Galvanized steel.
 - 6. Burglar Bars: **[1/2-inch- (13-mm-)][5/8-inch- (16-mm-)][3/4-inch- (20-mm-)]** thick steel bars welded in place to form **6-inch (150-mm)** squares.
 - 7. Mounting Pedestal: Galvanized steel with removable access panel.

2.13 VENTILATORS, CENTRIFUGAL - CEILING MOUNTED

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Acme Engineering & Manufacturing Corp.]**
 - 2. **[American Coolair Corporation]**
 - 3. **[Broan.; a Broan-NuTone LLC brand; a Nortek company]**
 - 4. **[Canarm Ltd.]**
 - 5. **[Carnes Company]**
 - 6. **[FloAire National]**
 - 7. **[Greenheck Fan Corporation]**



8. [JencoFan]
9. [Loren Cook Company]
10. [Panasonic Eco Solutions]
11. [PennBarry; division of Air System Components]
12. [S & P USA Ventilation Systems, LLC]
13. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Acme Engineering & Manufacturing Corp.]
2. [American Coolair Corporation]
3. [Broan.; a Broan-NuTone LLC brand; a Nortek company]
4. [Canarm Ltd.]
5. [Carnes Company]
6. [FloAire National]
7. [Greenheck Fan Corporation]
8. [JencoFan]
9. [Loren Cook Company]
10. [Panasonic Eco Solutions]
11. [PennBarry; division of Air System Components]
12. [S & P USA Ventilation Systems, LLC]
13. <Insert manufacturer's name>

C. Source Limitations: Obtain ceiling-mounted centrifugal ventilators from single manufacturer.

D. Standards: Comply with UL 705.

E. Housing: Steel, lined with acoustical insulation.

F. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel are removable for service.

G. Back-draft damper: Integral.

H. Grille: **[Plastic][Stainless steel][Aluminum][Painted aluminum]**, louvered grille with flange on intake and thumbscrew or spring retainer attachment to fan housing.

I. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

J. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless steel springs, and fusible link.
6. Filter: Washable aluminum to fit between fan and grille.
7. Isolation: Rubber-in-shear vibration isolators.
8. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.14 VENTILATORS, CENTRIFUGAL - ROOF-MOUNTED DOWNBLAST

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Acme Engineering & Manufacturing Corp.]**
 2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 3. **[Airmaster Fan; a brand of MAICO]**
 4. **[American Coolair Corporation]**
 5. **[Carnes Company]**
 6. **[FloAire National]**
 7. **[Greenheck Fan Corporation]**
 8. **[JencoFan]**
 9. **[Loren Cook Company]**
 10. **[New York Blower Company (The)]**
 11. **[Northern Blower, Inc.]**
 12. **[PennBarry; division of Air System Components]**
 13. **[Quietaire Inc.]**
 14. **[Rupp Air Management Systems]**
 15. **[S & P USA Ventilation Systems, LLC]**
 16. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Acme Engineering & Manufacturing Corp.]**
 2. **[Aerovent; a division of Twin City Fan Companies, Ltd.]**
 3. **[Airmaster Fan; a brand of MAICO]**
 4. **[American Coolair Corporation]**
 5. **[Carnes Company]**
 6. **[FloAire National]**
 7. **[Greenheck Fan Corporation]**
 8. **[JencoFan]**
 9. **[Loren Cook Company]**
 10. **[New York Blower Company (The)]**
 11. **[Northern Blower, Inc.]**
 12. **[PennBarry; division of Air System Components]**
 13. **[Quietaire Inc.]**
 14. **[Rupp Air Management Systems]**
 15. **[S & P USA Ventilation Systems, LLC]**
 16. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain roof-mounted downblast centrifugal ventilators from single manufacturer.
- D. Standards: Comply with UL 705.
- E. Housing: Downblast; removable **[spun-aluminum dome top and outlet baffle][extruded-aluminum rectangular top][galvanized-steel mushroom-domed top][spun aluminum]**; square, one-piece aluminum base with venturi inlet cone.
- F. Fan Wheels: Aluminum hub and wheel with backward-inclined blades[; **spark-resistant construction classified in accordance with AMCA 99, Section 8,][Type A][Type B][Type C]**.
- G. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through [5]<Insert number> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than [5]<Insert number> hp.
6. Fan and motor are isolated from exhaust airstream.

H. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted [inside][outside] fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
6. Spark-resistant, all-aluminum wheel construction.
7. Mounting Pedestal: Galvanized steel with removable access panel.

I. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: [Self-flashing without a cant strip, with mounting flange][Built-in cant and mounting flange][Built-in raised cant and mounting flange][Manufactured to accommodate roof slope].
2. Overall Height: [8 inches (203 mm)][9-1/2 inches (240 mm)][12 inches (305 mm)][16 inches (400 mm)][18 inches (450 mm)].
3. Sound Curb: Curb with sound-absorbing insulation.
4. Hinged sub-base to provide access to damper or as cleanout for grease applications.
5. Burglar Bars: [1/2-inch- (13-mm-)][5/8-inch- (16-mm-)][3/4-inch- (20-mm-)] thick steel bars welded in place to form 6-inch (150-mm) squares.
6. Pitch Mounting: Manufacture curb for roof slope.
7. Metal Liner: Galvanized steel.
8. Mounting Pedestal: Galvanized steel with removable access panel.

2.15 VENTILATORS, CENTRIFUGAL - ROOF-MOUNTED UPBLAST OR SIDEWALL MOUNTED

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Airmaster Fan; a brand of MAICO]
4. [American Coolair Corporation]
5. [Canarm Ltd.]
6. [Carnes Company]
7. [FloAire National]
8. [Greenheck Fan Corporation]

9. [JencoFan]
 10. [Loren Cook Company]
 11. [New York Blower Company (The)]
 12. [PennBarry; division of Air System Components]
 13. [Quietaire Inc.]
 14. [Rupp Air Management Systems]
 15. [S & P USA Ventilation Systems, LLC]
 16. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Acme Engineering & Manufacturing Corp.]
 2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
 3. [Airmaster Fan; a brand of MAICO]
 4. [American Coolair Corporation]
 5. [Canarm Ltd.]
 6. [Carnes Company]
 7. [FloAire National]
 8. [Greenheck Fan Corporation]
 9. [JencoFan]
 10. [Loren Cook Company]
 11. [New York Blower Company (The)]
 12. [PennBarry; division of Air System Components]
 13. [Quietaire Inc.]
 14. [Rupp Air Management Systems]
 15. [S & P USA Ventilation Systems, LLC]
 16. <Insert manufacturer's name>
- C. Source Limitations: Obtain roof-mounted upblast or sidewall-mounted centrifugal ventilators from single manufacturer.
- D. Standards:
1. Comply with UL 705.
 2. Power ventilators for use with restaurant kitchen exhaust are to comply with UL 762.
- E. Configuration: Centrifugal [roof upblast][roof upblast, kitchen grease hood][sidewall] ventilator.
- F. Housing: Removable [spun-aluminum dome top and outlet baffle][extruded-aluminum rectangular top][galvanized-steel, mushroom-domed top][spun aluminum]; square, one-piece aluminum base with venturi inlet cone.
1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
 2. [Provide grease collector.]
- G. Fan Wheels: Aluminum hub and wheel with backward-inclined blades[; spark-resistant construction classified in accordance with AMCA 99, Section 8,][Type A][Type B][Type C].
- H. Belt Drives:
1. Resiliently mounted to housing.
 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings; minimum ABMA 9, [L10 of 100,000 hours]<Insert life>.

4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through [5]<Insert number> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than [5]<Insert number> hp.
6. Fan and motor are isolated from exhaust airstream.

I. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted [inside][outside] fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
6. Mounting Pedestal: Galvanized steel with removable access panel.
7. Wall Mount Adapter: Attach wall-mounted fan to wall.
8. Restaurant Kitchen Exhaust: UL 762 listed for grease-laden air exhaust.

J. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: [Self-flashing without a cant strip, with mounting flange][Built-in cant and mounting flange][Built-in raised cant and mounting flange][Manufactured to accommodate roof slope].

K. Prefabricated Kitchen Exhaust Roof Curbs: Galvanized steel; mitered and welded corners; ventilation openings on all sides to ventilate curb interstitial space. Size as required to suit roof opening and fan base.

1. Configuration: [Self-flashing without a cant strip, with mounting flange][Built-in cant and mounting flange][Built-in raised cant and mounting flange][manufactured to accommodate roof slope].
2. Overall Height: [8 inches (203 mm)][9-1/2 inches (240 mm)][12 inches (305 mm)][16 inches (400 mm)][18 inches (450 mm)].
3. Sound Curb: Curb with sound-absorbing insulation[and galvanized metal liner].
4. Hinged sub-base to provide access to damper or as cleanout for grease applications.
5. Burglar Bars: [1/2-inch- (13-mm-)][5/8-inch- (16-mm-)][3/4-inch- (20-mm-)] thick steel bars welded in place to form 6-inch (150-mm) squares.
6. Pitch Mounting: Manufacture curb for roof slope.
7. Metal Liner: Galvanized steel.
8. Mounting Pedestal: Galvanized steel with removable access panel.
9. Vented Curb: For kitchen exhaust; 12-inch- (300-mm-) high galvanized steel; unlined, with louvered vents in vertical sides.
10. NFPA 96 code requirements for commercial cooking operations.
11. Kitchen Hood Exhaust: UL 762 listed for grease-laden air.

2.16 FANS, PROPELLER - SIDEWALL MOUNTED

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be

incorporated into the Work include, but are not limited to, the following]:

1. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Airmaster Fan; a brand of MAICO]
4. [American Coolair Corporation]
5. [Canarm Ltd.]
6. [Carnes Company]
7. [JencoFan]
8. [Loren Cook Company]
9. [Moffitt Corporation]
10. [Peerless Blowers]
11. [PennBarry; division of Air System Components]
12. [Quietaire Inc.]
13. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Airmaster Fan; a brand of MAICO]
4. [American Coolair Corporation]
5. [Canarm Ltd.]
6. [Carnes Company]
7. [JencoFan]
8. [Loren Cook Company]
9. [Moffitt Corporation]
10. [Peerless Blowers]
11. [PennBarry; division of Air System Components]
12. [Quietaire Inc.]
13. <Insert manufacturer's name>

- C. Source Limitations: Obtain sidewall-mounted propeller fans from single manufacturer.
- D. Standards: Comply with UL 705.
- E. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.
- F. Fan Wheels: Formed-steel blades riveted to heavy-gauge steel spider bolted to cast-iron hub.
- G. Fan Wheel: Replaceable, [cast][extruded]-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
- H. Fan Drive, Direct: Direct-drive motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- I. Fan Drive, Belt:
1. Belt drive.
 2. Resiliently mounted to housing.
 3. Statically and dynamically balanced.
 4. Selected for continuous operation at maximum-rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 5. Extend grease fitting to accessible location outside of unit.

6. Service Factor Based on Fan Motor Size: 1.4.
7. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
8. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, [L10 of 100,000 hours]<Insert life>.
9. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
10. Motor Pulleys: Adjustable pitch for use with motors through [5]<insert value> hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
11. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

J. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Dampers: Counterbalanced, parallel-blade, backdraft dampers factory set to close when fan stops.
3. Motorized Dampers: Parallel-blade dampers with electric actuator wired to close when fan stops.
4. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
5. Wall Sleeve: Galvanized steel to match fan and accessory size.
6. Weathershield Hood: Galvanized steel to match fan and accessory size.
7. Weathershield Front Guard: Galvanized steel with expanded metal screen.
8. Belt Guard: For motor mounted on outside of fan cabinet. Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; [0.146-inch- (2.7-mm-)]<Insert dimension> thick, [3/4-inch (20-mm)]<Insert dimension> diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

2.17 FANS, PROPELLER - ROOF-MOUNTED UPBLAST

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Acme Engineering & Manufacturing Corp.]
2. [Airmaster Fan; a brand of MAICO]
3. [American Coolair Corporation]
4. [Canarm Ltd.]
5. [Carnes Company]
6. [Greenheck Fan Corporation]
7. [Hartzell Fan Incorporated]
8. [JencoFan]
9. [Loren Cook Company]
10. [Moffitt Corporation]
11. [New York Blower Company (The)]
12. [Northern Blower, Inc.]
13. [PennBarry; division of Air System Components]
14. [Quietaire Inc.]
15. [Rupp Air Management Systems]
16. [S & P USA Ventilation Systems, LLC]
17. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Acme Engineering & Manufacturing Corp.]**
 2. **[Airmaster Fan; a brand of MAICO]**
 3. **[American Coolair Corporation]**
 4. **[Canarm Ltd.]**
 5. **[Carnes Company]**
 6. **[Greenheck Fan Corporation]**
 7. **[Hartzell Fan Incorporated]**
 8. **[JencoFan]**
 9. **[Loren Cook Company]**
 10. **[Moffitt Corporation]**
 11. **[New York Blower Company (The)]**
 12. **[Northern Blower, Inc.]**
 13. **[PennBarry; division of Air System Components]**
 14. **[Quietaire Inc.]**
 15. **[Rupp Air Management Systems]**
 16. **[S & P USA Ventilation Systems, LLC]**
 17. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain roof-mounted upblast propeller fans from single manufacturer.
- D. Standards: Comply with UL 705.
- E. Configuration: Upblast propeller ventilator.
- F. Wind Band, Fan Housing, and Base: Reinforced and braced **[galvanized steel][aluminum]**, containing **[galvanized-steel][aluminum]** butterfly dampers and rain trough, motor and drive assembly, and fan wheel.
1. Damper Rods: Steel with **[bronze][nylon]** bearings.
 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- G. Fan Wheel: Replaceable, **[cast][extruded]**-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades; **spark-resistant construction classified in accordance with AMCA 99, Section 8,][Type A][Type B][Type C]**.
- H. Belt Drives:
1. Resiliently mounted to housing.
 2. Weatherproof housing of same material as fan housing.
 3. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 4. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
 5. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 6. Motor Pulleys: Adjustable pitch for use with motors through **[5]<Insert number>** hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than **[5]<Insert number>** hp.
 7. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.
- I. Accessories:
1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted **[inside][outside]** fan housing, factory wired through an internal aluminum conduit.
 2. Bird Screens: Removable, **1/2-inch (13-mm)** mesh, aluminum or brass wire.
 3. Inspection Door: Hinged.



4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
6. Extended Lubrication Lines.
7. Belt Guard: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; **[0.146-inch- (2.7-mm-)]<Insert dimension> thick, [3/4-inch (20-mm)]<Insert dimension>** diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

J. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; **1-1/2-inch- (40-mm-)** thick, rigid, fiberglass insulation adhered to inside walls; and **1-1/2-inch (40-mm)** wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: **[Self-flashing without a cant strip, with mounting flange][Built-in cant and mounting flange][Built-in raised cant and mounting flange]**.
2. Overall Height: **[8 inches (203 mm)][9-1/2 inches (240 mm)][12 inches (305 mm)][16 inches (400 mm)][18 inches (450 mm)]**.
3. Sound Curb: Curb with sound-absorbing insulation.
4. Hinged sub-base to provide access to damper.
5. Burglar Bars: **[1/2-inch- (13-mm-)][5/8-inch- (16-mm-)][3/4-inch- (20-mm-)]** thick steel bars welded in place to form **6-inch (150-mm)** squares.
6. Pitch Mounting: Manufacture curb for roof slope.
7. Metal Liner: Galvanized steel.
8. Mounting Pedestal: Galvanized steel with removable access panel.

2.18 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
- B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.19 SOURCE QUALITY CONTROL

- A. **[AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.]**
- B. **[AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.]**
- C. **[AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.]**
- D. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.



PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install fans level and plumb.
- B. Disassemble and reassemble units, as required for moving to the final location, in accordance with manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.
- D. Equipment Mounting:
 - 1. Install floor-mounted fans on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Install roof-mounted fans on roof curbs or support steel. See Drawings for specific requirements.
 - 3. Unit Support: Install fans level on structural curbs. Coordinate with duct connections. **[Coordinate wall penetrations and flashing with wall construction.][Secure units to structural support with anchor bolts.]**
 - 4. Support duct-mounted and other hanging fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
 - 5. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 6. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Curb Support, Prefabricated: Rail-type wood support provided by fan manufacturer.
- F. Unit Support: Install centrifugal fans level on structural **[curbs][pilings]**. Coordinate with duct connections. **[Coordinate wall penetrations and flashing with wall construction.][Secure units to structural support with anchor bolts.]**
- G. Isolation Curb Support: Install centrifugal fans on isolation curbs, and install flexible duct connectors and vibration-isolation **[and seismic-control]** devices.
 - 1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 2. Comply with requirements in Section 230548.13 "Vibration Controls for HVAC."
- H. Install units with adequate clearances for service and maintenance.
- I. Label fans in accordance with requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."
- B. Where installing ducts adjacent to fans, allow space for service and maintenance.

3.3 PIPING CONNECTIONS

- A. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.
- B. Install heat tracing on all drain piping subject to freezing temperature and as indicated on Drawings. Furnish and install heat tracing in accordance with Section 230533 "Heat Tracing for HVAC Piping."

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.6 STARTUP SERVICE:

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 4. Verify that cleaning and adjusting are complete.
 - 5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
 - 6. For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - 7. Adjust belt tension.
 - 8. Adjust damper linkages for proper damper operation.
 - 9. Verify lubrication for bearings and other moving parts.

10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
11. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
12. Shut unit down and reconnect automatic temperature-control operators.
13. Remove and replace malfunctioning units and retest as specified above.

3.7 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Lubricate bearings.
- D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.8 CLEANING

- A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner][Contractor]** will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
 1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 2. Test and adjust controls and safeties.
 3. Fans and components will be considered defective if they do not pass tests and inspections.
 4. Prepare test and inspection reports.

3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain HVAC fans.

END OF SECTION 23 34 00 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 34 13 00	23 34 00 00	HVAC Fans
23 34 16 00	23 34 00 00	HVAC Fans
23 34 23 00	23 34 00 00	HVAC Fans



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 34 33 00 - COMMERCIAL AIR CURTAINS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Commercial air-curtain unit.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For air curtain units.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittal: For air curtain units indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by a qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-curtain unit mounting assemblies.
2. Include design calculations for selecting vibration isolators[**and seismic restraints**].

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranties: For special warranties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air curtain units to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Furnish one set of filters[**for each unit installed**].

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of air curtain units that fail in materials or workmanship within specified warranty period.
1. Warranty Period (Nonheating Units): **[60][24]<Insert number>** months.
 2. Warranty Period (Electric Heating Units): **[18][24]<Insert number>** months.
 3. Warranty Period (Hot-Water or Steam Heating Units): **[18][24]<Insert number>** months.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Unusual Service Conditions:

1. Base fan-performance ratings on the following:
 - a. Ambient Temperature: **<Insert number> deg F (deg C)**.
 - b. Altitude: **<Insert number> feet (m)** above sea level.
 - c. Humidity: **<Insert number> wet bulb deg F (deg C)**.
 - d. **<Insert conditions>**.

B. Capacities and Characteristics:

1. Application: **[Thermal barrier][Wind resistance][Interior separation][Fly and insect control]**.
2. Mounting Type: **[Suspension][Wall brackets][Keyhole wall mount]**.
3. Discharge Direction: Vertical.
4. Door Type: **[Exterior][Interior]**.
5. Door Height: **<Insert dimension> inches (mm)**.
6. Door Width: **<Insert dimension> inches (mm)**.
7. Unit Length: **[36 (900)][42 (1050)][48 (1200)][60 (1500)][72 (1800)][84 (2100)][96 (2400)][108 (2700)][120 (3000)][144 (3600)]<Insert dimension> inches (mm)**.
8. Net Weight: **<Insert number> lb (kg)**.
9. Nozzle Velocity: **<Insert number> fpm (m/s)**.
10. Average Outlet Velocity: **<Insert number> fpm (m/s)**.
11. Outlet Velocity Uniformity: **<Insert number> percent**.
12. Velocity Projection: **<Insert dimension> inches (mm)**.
13. Airflow: **<Insert number> cfm (L/s)**.
14. Intake: Internal.
15. Number of Fan(s): **[One][Two][Three][Four]<Insert number>**.
16. Fan Motor:
 - a. Electrical Characteristics:
 - 1) Horsepower: **[0.2][0.5]<Insert number> hp**.
 - 2) Volts: **[115][208][230][460]<Insert number> V**.
 - 3) Phase: **[Single][Three]**.
 - 4) Hertz: 60 Hz.
 - 5) Speed: **[1750]<Insert number> rpm**.
 - 6) Full-Load Amperes: **<Insert number> A**.
 - 7) Minimum Circuit Ampacity: **<Insert number> A**.
 - 8) Maximum Overcurrent Protection: **<Insert number> A**.

17. Sound Level Measured 10 Feet (3 m) from Nozzle: **<Insert number> dBA.**
18. Hot-Water Coil:
 - a. Entering-Water Temperature: **<Insert number> deg F (deg C).**
 - b. Leaving-Water Temperature: **<Insert number> deg F (deg C).**
 - c. Water Flow: **<Insert number> gpm (L/s).**
 - d. Water Pressure Drop: **<Insert number> feet of head (kPa).**
 - e. Air-Temperature Rise: **<Insert number> deg F (deg C).**
 - f. Number of Coil Row(s): **[One][Two]<Insert number>.**
19. Steam Coil:
 - a. Capacity: **<Insert number> MBh (kW).**
 - b. Air-Temperature Rise: **<Insert number> deg F (deg C).**
 - c. Number of Coil Row(s): **[One][Two]<Insert number>.**
 - d. Inlet Pressure: **[5]<Insert number> psig (kPa).**
 - e. Condensing Capacity: **<Insert number> lb/h (g/s).**
20. Electric Heater:
 - a. Capacity: **<Insert kilowatts>.**
 - b. Air-Temperature Rise: **<Insert number> deg F (deg C).**
 - c. Volts: **[115][208][230][460]<Insert number> V.**
 - d. Phase: **[Single][Three].**
 - e. Hertz: **60 Hz.**
 - f. Minimum Circuit Ampacity: **<Insert number> A.**
 - g. Maximum Overcurrent Protection: **<Insert number> A.**
 - h. Control Step(s): **[One][Two]<Insert number>.**

2.2 COMMERCIAL AIR-CURTAIN UNIT

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 1. **[Berner International]**
 2. **[Fantech]**
 3. **[Loren Cook Company]**
 4. **[Marley Engineered Products]**
 5. **[Mars Air Systems]**
 6. **[Powered Aire Inc.]**
 7. **[TMI, LLC; Cutron Products Division]**
 8. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Berner International]**
 2. **[Fantech]**
 3. **[Loren Cook Company]**
 4. **[Marley Engineered Products]**
 5. **[Mars Air Systems]**
 6. **[Powered Aire Inc.]**
 7. **[TMI, LLC; Cutron Products Division]**
 8. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain air curtain from single source from single manufacturer.
- D. Housing: **[Galvanized steel with electrostatically applied epoxy-enamel powder-coat finish][Type 304 stainless steel with No. 3 finish][Type 304 stainless steel with No. 4 finish][Type 316 stainless steel with No. 3 finish][Type 316 stainless steel with No. 4 finish]**.
1. Discharge Nozzle: Integral to housing, containing adjustable air-directional vanes with 40-degree sweep front to back.
- E. Mounting Brackets: Galvanized steel, for **[wall][ceiling]** mounting.
- F. Air-Intake Grilles:
1. Grilles: Integral to, and same material as, housing.
- G. Fans: **[Galvanized steel][Painted steel][Aluminum]**.
1. Centrifugal, forward curved, double width, double inlet.
 2. Statically and dynamically balanced.
 3. Direct drive.
- H. Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 2. Motor Speed: **[Single speed][Two speed][Multispeed][Variable speed]**.
 3. Resiliently mounted.
 4. Continuous duty.
 5. Totally enclosed, air over.
 6. Integral thermal-overload protection.
 7. Bearings: Permanently sealed, lifetime, prelubricated, ball bearings.
 8. Disconnect: **[Internal power cord with plug and receptacle][Lockable disconnect]<Insert disconnect type>**.
- I. Water Coils:
1. Type: **[Continuous circuit][Self-draining][Cleanable]**.
 2. Piping Connections: Threaded on **[same end][opposite ends]**.
 3. Tube Material: Copper, complying with ASTM B75/B75M.
 - a. Tube Diameter: **0.625 inch (15.9 mm)**.
 4. Fins: **[Aluminum][Copper]** with fin spacing **[0.167 (4.23)][0.125 (3.18)][0.091 (2.31)][0.071 (1.80)][0.067 (1.70)][0.056 (1.42)][0.0075 (0.19)]<Insert dimension> inch (mm)**.
 5. Fin and Tube Joint: Mechanical bond.
 6. Headers: Seamless copper tube with brazed joints, prime coated.
 7. Frames: Galvanized-steel channel frame, **[0.052 (1.3)][0.064 (1.6)][0.079 (2.0)][0.0625 (1.59)]<Insert dimension> inch (mm)**.
 8. Ratings: In accordance with ASHRAE 33.
 9. Working-Pressure Ratings: **200 psig (1380 kPa), 325 deg F (163 deg C)**.
- J. Steam Coils: **[Distribution-header][Single-tube]** coil, with threaded steam supply and condensate connections.

1. Piping Connections: **[Same end][Opposite ends][Steam supply on both ends; condensate on one end]**.
2. Tube Material: Copper, complying with ASTM B75/B75M.
3. Tube Diameter: **0.625 inch (15.9 mm)**.
4. Fins: Aluminum, with fin spacing **[0.167 (4.23)][0.125 (3.18)][0.091 (2.31)][0.071 (1.80)][0.067 (1.70)][0.056 (1.42)][0.0075 (0.19)]<Insert dimension> inch (mm)**.
5. Fin and Tube Joint: Mechanical bond.
6. Headers: Seamless copper tube with brazed joints, prime coated.
7. Frames: Galvanized-steel channel frame, **[0.052 (1.3)][0.064 (1.6)][0.079 (2.0)][0.0625 (1.59)]<Insert dimension> inch (mm)**.
8. Pressure and Temperature Ratings: **100 psig (690 kPa), 400 deg F (205 deg C)** in accordance with ASHRAE 33.

K. Electric-Resistance Coils:

1. Coil Assembly: Comply with UL 1995.
2. Frame: Galvanized-steel frame.
3. Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
4. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or unit.
 - a. **[Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.]**
5. Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection. Include the following controls:
 - a. Magnetic contactor.
 - b. **[Solid-state stepless pulse][Step]** controller.
 - c. **[Time-delay relay.]**
 - d. **[Pilot lights; one per step.]**
 - e. Airflow-proving switch.

L. Filters:

1. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with glass-fiber media sprayed with nonflammable adhesive in **[cardboard][galvanized-steel]** frame.
2. Washable Panel Filters: Removable, **[aluminum][stainless steel]**, baffle-type filters with spring-loaded fastening; with minimum **0.0781-inch- (1.984-mm-)** thick, stainless steel filter frame.
3. Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.

M. Controls:

1. Thermostat: **[Built-in][Remote, field-installed]; [line voltage][24 V]**, factory installed and wired to **[junction box on air curtain][motor-control panel]**.
2. Automatic Door Switch: **[Roller type][Combination roller-plunger type][Plunger type][Magnetic]**, installed in door area to activate air curtain when door opens and to deactivate air curtain when door closes.
3. Start-Stop, Push-Button Switch: Manually activates and deactivates air curtain.
4. Three-Speed Switch: Manually activates, deactivates, and controls air-curtain fan speed.
5. **[Time-Delay Relay: Factory installed and adjustable to allow air curtain to operate from 0.5 seconds to 10 hours.]**

6. Motor-Control Panel: Complete with motor starter, 115-V ac transformer with primary and secondary fuses, terminal strip, and NEMA 250, [Type 1][Type 12] enclosure [with door-mounted, HAND-OFF-AUTO switch][with built-in, variable fan-speed control].

N. Accessories:

1. Mounting Brackets: Adjustable mounting brackets for [wall][top] mounting.
2. Discharge Extension Neck: For ceiling-recessed installation.

2.3 SOURCE QUALITY CONTROL

- A. Source Quality Control: Test to **300 and 200 psig (2070 and 1380 kPa)** underwater.
- B. Testing: Test and inspect steam coils in accordance with ASHRAE 33.
- C. AMCA Certification for Fan Aerodynamic Performance Rating: Test, rate, and label, air curtain units in accordance with AMCA 211.
- D. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label, air curtain units in accordance with AMCA 311.
- E. Comply with AHRI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils," for components, construction, and rating.
- F. Comply with NSF 37, "Air Curtains for Entranceways in Food and Food Service Establishments."
- G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
- H. Steam coil will be considered defective if it does not pass tests and inspections.
- I. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine work areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for [hot-water][steam and condensate] piping systems to verify actual locations of piping connections before air-curtain installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install air curtains with clearance for equipment service and maintenance.
- B. Equipment Installation: Install air curtains[with seismic-restraint devices]. Comply with requirements

for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

- C. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 PIPING CONNECTIONS

- A. Comply with requirements for heating hot-water piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for steam piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 ADJUSTING

- A. Adjust motor speed to achieve specified airflow.
- B. Adjust discharge louver and dampers to regulate airflow.
- C. Adjust air-directional vanes.



3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner][Contractor]** will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections **[with the assistance of a factory-authorized service representative]**.
- D. Tests and Inspections:
 - 1. After installing air curtains completely, perform visual and mechanical check of individual components.
 - 2. After electrical circuitry has been energized, start unit to confirm motor rotation and unit operation. Certify compliance with test parameters.
 - 3. Inspect for **[water][steam and condensate]** leaks.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Air-curtain unit will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.8 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain commercial air curtains.

END OF SECTION 23 34 33 00



SECTION 23 34 33 00A - INDUSTRIAL AIR CURTAINS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Industrial air-curtain unit.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include rated capacities, operating characteristics, performance characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For air curtain units.
1. Include plans, elevations, sections, and attachment details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
- C. Delegated Design Submittal: For air curtain units indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Detail fabrication and assembly of air-curtain unit mounting assemblies.
 2. Include design calculations for selecting vibration isolators[**and seismic restraints**].

1.3 INFORMATIONAL SUBMITTALS

- A. Sample Warranties: For special warranties.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air curtains to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Furnish one set of filters.
 2. Furnish one set of fan belts for each unit.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of air curtains that fail in materials or workmanship within specified warranty period.
1. Warranty Period (Nonheating Units): [24]<Insert number> months.
 2. Warranty Period (Water or Steam Heating Units): [18][24]<Insert number> months.
 3. Warranty Period (Gas Heating Units): [18][24]<Insert number> months.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Unusual Service Conditions:

1. Base fan-performance ratings on the following:
 - a. Ambient Temperature: <Insert number> deg F (deg C).
 - b. Altitude: <Insert number>feet (m) above sea level.
 - c. Humidity: <Insert number> wet bulb deg F (deg C).
 - d. <Insert conditions>.

B. Capacities and Characteristics:

1. Application: [Thermal barrier][Wind resistance][Interior separation][Fly and insect control].
2. Mounting Type: [Suspension][Wall brackets][Keyhole wall mount].
3. Discharge Direction: [Horizontal][Vertical].
4. Door Type: [Exterior][Interior].
5. Door Height: <Insert dimension> inches (mm).
6. Door Width: <Insert dimension> inches (mm).
7. Unit Length: <Insert dimension> inches (mm).
8. Net Weight: <Insert number> lb (kg).
9. Nozzle Velocity: [1000 (5)]<Insert number> fpm (m/s).
10. Average Outlet Velocity: <Insert number> fpm (m/s).
11. Outlet Velocity Uniformity: <Insert number> percent.
12. Velocity Projection: <Insert dimension> inches (mm).
13. Airflow: <Insert number> cfm (L/s).
14. Intake: [Internal][External].
15. Number of Fan(s): [One][Two][Three]<Insert number>.
16. Fan Motor:
 - a. Electrical Characteristics:
 - 1) Horsepower: [0.5][1][2][3]<Insert number> hp.
 - 2) Volts: [115][208][230][460]<Insert number> V.
 - 3) Phase: [Single][Three].
 - 4) Hertz: 60 Hz.
 - 5) Speed: [1750]<Insert number> rpm.
 - 6) Full-Load Amperes: <Insert number> A.
 - 7) Minimum Circuit Ampacity: <Insert number> A.
 - 8) Maximum Overcurrent Protection: <Insert number> A.
17. Sound Level Measured 10 Feet (3 m) from Nozzle: <Insert number> dBA.

18. Hot-Water Coil:

- a. Entering-Water Temperature: **<Insert number> deg F (deg C).**
- b. Leaving-Water Temperature: **<Insert number> deg F (deg C).**
- c. Water Flow: **<Insert number> gpm (L/s).**
- d. Water Pressure Drop: **<Insert number> feet of head (kPa).**
- e. Air-Temperature Rise: **<Insert number> deg F (deg C).**
- f. Number of Coil Row(s): **[One][Two]<Insert number>.**

19. Steam Coil:

- a. Capacity: **<Insert number> MBh (kW).**
- b. Air-Temperature Rise: **<Insert number> deg F (deg C).**
- c. Number of Coil Row(s): **[One][Two]<Insert number>.**
- d. Inlet Pressure: **<Insert number> psig (kPa).**
- e. Condensing Capacity: **<Insert number> lb/h (g/s).**

20. Electric Heater:

- a. Capacity: **<Insert kilowatts>.**
- b. Air-Temperature Rise: **<Insert number> deg F (deg C).**
- c. Volts: **[115][208][230][460]<Insert number> V.**
- d. Phase: **[Single][Three].**
- e. Hertz: **60 Hz.**
- f. Minimum Circuit Ampacity: **<Insert number> A.**
- g. Maximum Overcurrent Protection: **<Insert number> A.**
- h. Control Step(s): **[One][Two][Three]<Insert number>.**

21. Gas-Fired Heaters:

- a. Capacity: **<Insert number> Btu/h (W) at <Insert number> inch wg (Pa) gas pressure.**
- b. Air-Temperature Rise: **<Insert number> deg F (deg C).**

2.2 INDUSTRIAL AIR-CURTAIN UNIT

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Berner International]**
2. **[Fantech]**
3. **[Loren Cook Company]**
4. **[Marley Engineered Products]**
5. **[Mars Air Systems]**
6. **[Powered Aire Inc.]**
7. **[TMI, LLC; Cutron Products Division]**
8. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Berner International]**
2. **[Fantech]**
3. **[Loren Cook Company]**
4. **[Marley Engineered Products]**



5. **[Mars Air Systems]**
6. **[Powered Aire Inc.]**
7. **[TMI, LLC; Cutron Products Division]**
8. **<Insert manufacturer's name>**

C. Source Limitations: Obtain air curtain from single source from single manufacturer.

D. Housing:

1. Galvanized Steel: Galvanized steel with electrostatically applied, epoxy-enamel, powder-coat finish.
2. Electroplated Steel: Heavy-gauge, electroplated-zinc steel with welded construction and polyester-coated finish.
3. Aluminum: Heavy-gauge, aluminum construction.
 - a. Anodized Finish: Match finish and color of adjacent architectural metals. Comply with NAAMM/NOMMA 500 for recommendations for applying and designating finishes.
 - b. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 1) Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: Nonspecular as fabricated; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
 - 2) Class II, Color Anodic Finish: AA-M12C22A32/A34 (Mechanical Finish: Nonspecular as fabricated; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker).
4. Materials: Stainless steel.
5. Fixed Discharge Nozzle: Integral part of the housing, containing fixed air-directional vanes.
6. Adjustable Discharge Nozzle: Integral part of the housing, containing adjustable air-directional vanes with **[40]<Insert number>**-degree sweep front to back.

E. Mounting Brackets: Steel, for **[wall][ceiling]** mounting.

F. Air-Intake Louvers: Comply with requirements in Section 089000 "Louvers and Vents."

G. Air-Intake:

1. Louvers: Integral part of and same material as the housing, mechanically field adjustable and capable of reducing air-outlet velocity by **[60]<Insert number>** percent with louver in totally closed position.
2. Grille: Integral part of and same material as the housing.
3. Insect Screen: **[Aluminum][Stainless steel]**, removable.

H. Fans:

1. **[Centrifugal, forward curved, double width, double inlet][Vane axial]**.
2. **[Galvanized steel][Painted steel][Aluminum]**.
3. Statically and dynamically balanced.
4. **[Direct drive][Belt drive, equipped with belt guards, adjustable sheaves, and pulleys]**.

I. Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. **[Single speed][Two speed][Multispeed]**.
3. Resiliently mounted.
4. Continuous duty.
5. **[Totally enclosed, air over][Totally enclosed, fan cooled][Open, dripproof][Explosion proof]**.
6. Integral thermal-overload protection.
7. Bearings: Permanently sealed, lifetime, prelubricated, ball bearings.
8. Disconnect: Internal power cord with plug and receptacle.

J. Water Coils:

1. Type: **[Continuous circuit][Self-draining][Cleanable]**.
2. Piping Connections: Threaded on **[same end][opposite ends]**.
3. Tube Material: Copper, complying with ASTM B75/B75M.
 - a. Tube Diameter: **0.625 inch (15.9 mm)**.
4. Fins: **[Aluminum][Copper]** with fin spacing **[0.167 (4.23)][0.125 (3.18)][0.091 (2.31)][0.071 (1.80)][0.067 (1.70)][0.056 (1.42)][0.0075 (0.19)]<Insert dimension> inch (mm)**.
5. Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
6. Headers: **[Cast iron with drain and air vent tappings][Cast iron with cleaning plugs, and drain and air vent tappings][Seamless copper tube with brazed joints, prime coated][Fabricated steel with brazed joints, prime coated]**.
7. Frames: Galvanized-steel channel frame, **[0.052 (1.3)][0.064 (1.6)][0.079 (2.0)][0.0625 (1.59)]<Insert dimension> inch (mm)**.
8. Ratings: In accordance with ASHRAE 33.
9. Working-Pressure Ratings: **200 psig (1380 kPa), 325 deg F (163 deg C)**.

K. Steam Coils: **[Distribution-header][Single-tube]** coil, with threaded steam supply and condensate connections.

1. Piping Connections: **[Same end][Opposite ends][Steam supply on both ends; condensate on one end]**.
2. Tube Material: Copper, complying with ASTM B75/B75M.
3. Tube Diameter: **0.625 inch (15.9 mm)**.
4. Fins: **[Aluminum][Copper]** with fin spacing **[0.167 inch (4.23 mm)][0.125 inch (3.18 mm)][0.091 inch (2.31 mm)][0.071 inch (1.80 mm)][0.067 inch (1.70 mm)][0.056 inch (1.42 mm)][0.0075 inch (0.19 mm)]**.
5. Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
6. Headers: **[Cast iron with drain and air vent tappings][Cast iron with cleaning plugs, and drain and air vent tappings][Seamless copper tube with brazed joints, prime coated][Fabricated steel with brazed joints, prime coated]**.
7. Frames: Galvanized-steel channel frame, **[0.052 (1.3)][0.064 (1.6)][0.079 (2.0)][0.0625 (1.59)]<Insert dimension> inch (mm)**.
8. Pressure and Temperature Ratings: **100 psig (690 kPa), 400 deg F (205 deg C)** in accordance with ASHRAE 33.

L. Electric-Resistance Coils:

1. Coil Assembly: Comply with UL 1995.
2. Frame: Galvanized-steel frame.
3. Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
4. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device;

serviceable through terminal box without removing heater from duct or unit.

- a. **[Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.]**
5. Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection. Include the following controls:
 - a. Magnetic contactor.
 - b. **[Solid-state stepless pulse][Step]** controller.
 - c. Toggle switches; one per step.
 - d. **[Time-delay relay.]**
 - e. **[Pilot lights; one per step.]**
 - f. Airflow-proving switch.

M. Gas-Fired Heaters:

1. Comply with ANSI Z83.8/CSA 2.6, "Gas Unit Heaters and Gas-Fired Duct Furnaces."
 - a. CSA Approval: Bear CSA label.
 - b. Type of Gas: **[Natural][Liquefied petroleum (LP)]**.
2. Assembly and Wiring: Heaters factory assembled, piped, wired, and tested for 120 V ac.
3. Housing: Steel, with integral draft hood and inserts for suspension-mounted rods.
4. External Casings and Cabinets: Baked enamel over corrosion-resistant-treated surface.
5. Heat Exchanger: **[Aluminized][Stainless]** steel.
6. Burners: Cast iron or aluminized steel with stainless steel inserts.
7. Gravity vent.
8. Power Venter: 120 V ac, with stainless steel shaft.
9. Automatic Gas Control: **[Single][Two]**-stage, 24-V ac valve.
10. Ignition: **[Standing pilot][Electronically controlled spark with flame sensor]**.

N. Filters:

1. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with glass-fiber media sprayed with nonflammable adhesive in **[cardboard][galvanized-steel]** frame.
2. Washable Panel Filters: Removable, stainless steel, baffle-type filters with spring-loaded fastening; with minimum **0.0781-inch- (1.984-mm-)** thick, stainless steel filter frame.
3. Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.

O. Controls:

1. Thermostat: **[Built-in][Remote, field-installed]**, **[line voltage][24 V]**, factory installed and wired to **[junction box on air curtain][motor-control panel]**.
2. Automatic Door Switch: **[Roller type][Combination roller-plunger type][Plunger type][Magnetic]**, installed in door area to activate air curtain when door opens and to deactivate air curtain when door closes.
3. Start-Stop, Push-Button Switch: Manually activates and deactivates air curtain.
4. Three-Speed Switch: Manually activates, deactivates, and controls air-curtain fan speed.
5. **[Time-Delay Relay: Factory installed and adjustable to allow air curtain to operate from 0.5 seconds to 10 hours.]**
6. Motor-Control Panel: Complete with motor starter, 115-V ac transformer with primary and secondary fuses, terminal strip, and NEMA 250, **[Type 1][Type 12]** enclosure **[with door-**

mounted, HAND-OFF-AUTO switch][with built-in, variable fan-speed control].

P. Accessories:

1. Mounting Brackets: Adjustable mounting brackets for drum-type roll-up doors.

2.3 SOURCE QUALITY CONTROL

- A. Source Quality Control: Test to **300 and 200 psig (2070 and 1380 kPa)** underwater.
- B. Testing: Test and inspect steam coils in accordance with ASHRAE 33.
- C. AMCA Certification for Fan Aerodynamic Performance Rating: Test, rate, and label air curtain units in accordance with AMCA 211.
- D. Comply with AHRI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils," for components, construction, and rating.
- E. Comply with NSF 37, "Air Curtains for Entranceways in Food and Food Service Establishments."
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
- G. Steam coil will be considered defective if it does not pass tests and inspections.
- H. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for **[hot-water][steam][gas]** piping systems to verify actual locations of piping connections before air-curtain installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install air curtains with clearance for equipment service and maintenance.
- B. Equipment Installation: Install air curtains **[with seismic-restraint devices]**. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- C. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."



3.3 PIPING CONNECTIONS

- A. Comply with requirements for heating hot-water piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for steam piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Comply with requirements for natural-gas piping specified in Section 231123 "Facility Natural-Gas Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- D. Comply with requirements for LP gas piping specified in Section 231126 "Facility Liquefied-Petroleum Gas Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- E. Where installing piping adjacent to equipment, allow space for service and maintenance.
- F. Breeching: Comply with applicable requirements in Section 235116 "Fabricated Breechings and Accessories." Connect breeching to full size at flue outlet.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 ADJUSTING

- A. Adjust belt tension.
- B. Adjust motor and fan speed to achieve specified airflow.

- C. Adjust discharge louver and dampers to regulate airflow.
- D. Adjust air-directional vanes.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner][Contractor]** will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 - 1. After installing air curtains completely, perform visual and mechanical check of individual components.
 - 2. After electrical circuitry has been energized, start unit to confirm motor rotation and unit operation. Certify compliance with test parameters.
 - 3. Inspect for water leaks.
 - 4. Test gas train and verify that there are no gas leaks.
 - 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Air-curtain unit will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.8 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain industrial air curtains.

END OF SECTION 23 34 33 00A



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 34 33 00	23 34 00 00	HVAC Fans



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 34 39 00 - HIGH-VOLUME, LOW-SPEED FANS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes high-volume, low-speed fans.

1.2 DEFINITIONS

- A. HVLS - High volume, low speed.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, furnished specialties, and accessories for each fan.
 - 2. Certified fan performance curves with system operating conditions indicated.
 - 3. Certified fan sound-power ratings.
 - 4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 5. Material thickness and finishes, including color charts.
 - 6. Fan speed controllers.
- B. Sustainable Design Submittals:
 - 1. Product Data for EA Prerequisite 3, "Fundamental Refrigerant Management": For refrigerants, indicating compliance with refrigerant management practices.
 - 2. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
 - 3. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
 - 4. Product Data for EA Prerequisite 2, "Minimum Energy Performance": Indicating compliance with minimum energy performance requirements.
 - 5. Product Data: Indicating compliance with minimum energy performance requirements.
 - 6. Product Data: For minimum energy performance.
 - 7. Product Data for Credit IEQ 6.2, "Controllability of Systems - Thermal Comfort": Documentation indicating that systems, equipment, and controls comply.
 - 8. Thermal Comfort: Product Data indicating that systems, equipment, and controls comply.
 - 9. Product Data for Credit IEQ 7.1, "Thermal Comfort - Design": Documentation indicating that systems, equipment, and controls comply.
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Show dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- D. Delegated-Design Submittal: For each HVLS fan.
 - 1. Include design calculations and details for selecting product mounting components and seismic

restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic forces required to select mounting components and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and details, drawn to scale and coordinated with each other, using input from installers of the items involved.
- B. Qualification Data:
 1. For Installer: Certificate from HVLS fan manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, controls, and accessories indicated and furnished for installation.
- C. Seismic-Restraint Details:
 1. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 2. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 3. Preapproval and Evaluation Documentation: By **[an evaluation service member of ICC-ES][Office of Statewide Health Planning and Development][an agency acceptable to authorities having jurisdiction]**, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVLS fans to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Provide certification that manufacturer complies with **[the most recent edition of ISO 9001]<Insert requirement>**.
- B. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by HVLS fan manufacturer.
 1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, controls, and accessories indicated and furnished for installation.
 2. Installer certification shall be valid and current for duration of Project.
 3. Retain copies of Installer certificates on-site and make available on request.
 4. Each person assigned to Project shall have demonstrated past experience.

- a. Demonstrated past experience with products being installed for period within **[three][five]<Insert number>** consecutive years before time of bid.
- b. Demonstrated past experience on **[five]<Insert number>** projects of similar complexity, scope, and value.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean and dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
- E. Replace installed products damaged during construction.

1.8 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of fans that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. For Motor, Including Controls: **[Five][Seven][10]<Insert number>** year(s) from date of Substantial Completion.
 - b. For Parts, Including Blades and Hub: **[Five][Seven][10]<Insert number>** year(s) from date of Substantial Completion.
 - c. For Labor: **[One][Two]<Insert number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Listed and labeled to UL 507.
- C. CSA Compliance: Listed and labeled to CSA C22.2, No. 113.
- D. Comply with NFPA 13 requirements for HVLS fans.



- E. AMCA Compliance:
 - 1. Test HVLS fans according to AMCA 230.
 - 2. Certify HVLS fan performance according to AMCA 211.
- F. Performance Data: Comply with ANSI 230 test procedure standard, based on five rating points: 20-, 40-, 60-, 80-, and 100-percent of maximum speed. Comply with AMCA 211 for publication of performance data.
- G. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design HVLS ceiling fans.
- H. Seismic Performance: HVLS ceiling fans shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the HVLS fans will remain in place without separation of any parts when subjected to the seismic forces specified[**and the units will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Fan:
 - 1. Type: HVLS **[Upflow][Downflow][Selectable]**.
 - 2. Number of Fan Blades: **<Insert number>**.
 - 3. Fan Diameter: **<Insert value> feet (m)**.
 - 4. Maximum Fan Speed: **<Insert rpm>**.
 - 5. Fan Airflow at AMCA Rating Points **cfm (L/s)**:
 - a. Airflow at 20 Percent: **<Insert value>**.
 - b. Airflow at 40 Percent: **<Insert value>**.
 - c. Airflow at 60 Percent: **<Insert value>**.
 - d. Airflow at 80 Percent: **<Insert value>**.
 - e. Airflow at 100 Percent: **<Insert value>**.
 - 6. Fan Discharge Sound Power at Maximum Speed, dB:
 - a. 1st Octave: **<Insert value>**.
 - b. 2nd Octave: **<Insert value>**.
 - c. 3rd Octave: **<Insert value>**.
 - d. 4th Octave: **<Insert value>**.
 - e. 5th Octave: **<Insert value>**.
 - f. 6th Octave: **<Insert value>**.
 - g. 7th Octave: **<Insert value>**.
 - h. 8th Octave: **<Insert value>**.
- B. Motor:
 - 1. Size: **<Insert horsepower>**.
 - 2. Speed: **<Insert rpm>**.
 - 3. Volts: **[120][208][230][277][460]<Insert value> V**.

4. Phase: **[Single][Three]<Insert number>**.
5. Hertz: **[60]<Insert number> Hz**.
6. Full-Load Amperes: **<Insert value> A**.
7. Minimum Circuit Ampacity: **<Insert value> A**.
8. Maximum Overcurrent Protection: **<Insert amperage> A**.

2.3 HIGH-VOLUME, LOW-SPEED FANS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Big Ass Fans]**
 2. **[Blue Giant Equipment Corporation]**
 3. **[Glocon Inc.]**
 4. **[Hunter Fan Company; Industrial & Commercial Division]**
 5. **[Kelley; Entrematic; ASSA ABLOY]**
 6. **[MacroAir]**
 7. **[Rite-Hite Holding Corporation]**
 8. **[Thermotek]**
 9. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Big Ass Fans]**
 2. **[Blue Giant Equipment Corporation]**
 3. **[Glocon Inc.]**
 4. **[Hunter Fan Company; Industrial & Commercial Division]**
 5. **[Kelley; Entrematic; ASSA ABLOY]**
 6. **[MacroAir]**
 7. **[Rite-Hite Holding Corporation]**
 8. **[Thermotek]**
 9. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain HVLS fans from single source from single manufacturer.
- D. Description: Factory-assembled and -tested horizontal, non-ducted fan unit, consisting of large-diameter blade set, direct-drive electric motor, with **[speed-reducing gearbox][variable-speed motor controller]**.
1. Provide fan designed to circulate large air volume, vertically, at low velocity.
 2. Maximum Operating Temperature: **[122 (50)][140 (60)]<Insert value> deg F (deg C)**.
 3. Frame:
 - a. Material: **[Aluminum][Galvanized steel][Stainless steel]<Insert metal>**.
 - 1) Finish: **[Paint][Powdercoat][Thermoset, polyester powder paint][Anodized]<Insert finish>**.
 4. Diameter: **[8 (2.4)][10 (3.0)][12 (3.7)][14 (4.3)][16 (4.9)][18 (5.5)][20 (6.1)][24 (7.3)]<Insert diameter> feet (m)**.
 5. Blades: Airfoil type.
 - a. Quantity: **[3]<Insert number>**.



- b. Material: **[Aluminum]<Insert material>**.
- 1) Blade Finish: **[Anodized]<Insert finish>**.
- 6. Motor: **[Squirrel cage]**, **[integral to fan frame]****[totally enclosed fan cooled]****[ODP]****[explosion proof]<Insert motor enclosure class>**.
- 7. Wiring and Controls Enclosure:
 - a. NEMA 250, **[Class 1]****[Class 4]****[Class 4X]<Insert NEMA enclosure class>**.
 - b. Material: **[Aluminum]****[Galvanized steel]****[Stainless steel]<Insert metal>**.
 - 1) Enclosure Finish: **[Paint]****[Powdercoat]****[Thermoset]****[Polyester powder paint]****[Anodized]****[Polished]<Insert finish>**.
 - c. Grounded.
- 8. Controls: Provide **[wall-mounted keypad]<Insert controlling device>**.
 - a. Provide **[fixed]****[automatic]****[manual]****[variable speed motor controller]****[Insert speed control component here]** speed control.
- 9. Maximum Sound Power Level: **<Insert value>** dBA.
- 10. Standard Mounting Bracket: Steel beam/steel angle.
- 11. Mounting Bracket: **[Large beam]****[Solid beam]****[Z-purlin]<Insert mounting bracket type>**.
- 12. Accessories:
 - a. Mounting extension tube.
 - b. **<Insert accessory option here>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting HVLS fan performance, maintenance, and operations.
 - 1. Fan locations indicated on Drawings are approximate. Determine exact locations before roughing-in for mounting, control, and electrical connections.
- B. Examine roughing-in for mounting location, anchor-bolt sizes, and locations, to verify actual locations for mounting connections before installation of fan.
- C. Examine areas for suitable conditions where fan will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HIGH-VOLUME LOW-SPEED FANS

- A. Install fan according to manufacturer's published instructions.
- B. Comply with NECA 1 and NFPA 70.

- C. Comply with NFPA 13 for installation of HVLS fans and maximum allowable fan diameter. Center HVLS fans between four adjacent sprinklers. Minimum vertical clearance from HVLS fan to sprinkler deflector is **3 feet (0.9 m)**.
- D. Comply with NFPA 72 and interlock HVLS fans to shut down upon receiving an alarm from fire alarm system.
- E. Equipment Mounting:
 - 1. Anchor fan to building structure **[with manufacturer's recommended mounting bracket][as shown in approved delegated design]** for installed condition.
 - 2. Consult a licensed professional structural engineer for mounting methods and approval for mounting to the structure. Structure must be able to withstand the torque and forces generated by the fan.
 - 3. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
 - 4. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 5. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- F. Install unit to permit access for maintenance.
- G. Install parts and accessories shipped loose.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.
- E. Install power wiring to field-mounted electrical devices, furnished by fan manufacturer, but not factory mounted.

3.4 CONTROL CONNECTIONS

- A. Connect control wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."
- C. Connect control interlock wiring between HVLS fan and other equipment to provide a complete and functioning system.

- D. Connect control wiring between fan unit control interface and control system to provide remote control and monitoring.
- E. Install control devices furnished by manufacturer, but not factory mounted.
- F. Install control wiring to field-mounted control devices, furnished by fan manufacturer, but not factory mounted.
- G. Protect installed units from damage caused by other work.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency, Owner Engaged: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency, Contractor Engaged: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Fan or components will be considered defective if fan or components do not pass tests and inspections.
- F. Prepare and submit test and inspection reports.

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that fan is secure on mountings and supporting devices and that connections to electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers and switches.
 - 3. Verify proper motor rotation direction and free fan rotation.
 - 4. Check bearing **[and gearbox]** lubrication.
 - 5. Verify proper fan rotation. **[Set rotation selector to blow vertically downward during heating season, and vertically upward during cooling season.]**

3.7 ADJUSTING

- A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.



3.8 CLEANING

- A. Clean equipment externally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions. Following manufacturer's cleaning procedures, and clean with manufacturer-recommended cleaning products.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain HVLS fans.
- B. Video training sessions, and provide electronic copy of video to Owner.

END OF SECTION 23 34 39 00



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 35 00 00 - LISTED KITCHEN VENTILATION SYSTEM EXHAUST DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. UL-listed, factory-fabricated grease duct - double-wall, 2-hour fire-rated, zero clearance.
2. UL-listed, factory-fabricated grease duct - double wall, reduced clearance.
3. UL-listed, factory-fabricated grease duct - single wall.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for UL-listed grease ducts.

B. Shop Drawings: For UL-listed, factory-fabricated grease ducts.

1. Plans, elevations, sections, and attachment details.
2. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Details of fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following welding codes:

1. AWS D1.1/D1.1M.
2. AWS D9.1/D9.1M.

PART 2 - PRODUCTS

2.1 UL-LISTED, FACTORY-FABRICATED GREASE DUCT - DOUBLE-WALL, 2-HOUR FIRE-RATED, ZERO CLEARANCE

- A. Manufacturers:** Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. [Ampco Stacks; DuraVent]
2. [DuraVent]
3. [Jeremias Inc.]
4. [Metal-Fab, Inc]
5. [Schebler Co. (The)]
6. [Security Chimneys; DuraVent]
7. [Selkirk Corporation; DuraVent]
8. [Van-Packer Co.]
9. [Ventilation Direct]
10. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Ampco Stacks; DuraVent]
2. [DuraVent]
3. [Jeremias Inc.]
4. [Metal-Fab, Inc]
5. [Schebler Co. (The)]
6. [Security Chimneys; DuraVent]
7. [Selkirk Corporation; DuraVent]
8. [Van-Packer Co.]
9. [Ventilation Direct]
10. <Insert manufacturer's name>

C. Description: Factory-fabricated, UL-listed and -labeled, double-wall, 2-hour, fire-rated duct system tested in accordance with UL 1978 and UL 2221 and rated for **500 deg F (260 deg C)** continuously, or **2000 deg F (1093 deg C)** for 30 minutes; with positive or negative duct pressure and complying with NFPA 96.

D. Construction: Inner shell and outer jacket separated by at least a [1-inch (25-mm)][2-inch (50-mm)][3-inch (75-mm)][4-inch (100-mm)] annular space filled with high-temperature, ceramic-fiber insulation, and complying with zero inches clearance to combustibles.

1. Inner Shell: ASTM A666, [Type 304][Type 316] stainless steel.
2. Outer Jacket: [Aluminized][ASTM A666 stainless] steel where concealed from occupied space. Stainless steel where exposed to occupied space.

E. Gaskets and Flanges: Ensure that gaskets and sealing materials are rated at **1500 deg F (816 deg C)** minimum.

F. Hood Connectors: Constructed from same material as grease duct with internal or external continuously welded or brazed joints.

G. Accessories: Tees, elbows, increasers, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters, and drain fittings.

H. Grease Duct Access Doors: Provide access doors where indicated and where necessary for cleaning and inspection of duct interior.

1. Description: Factory-fabricated, -listed, and -labeled, double-wall [personnel][and][maintenance] access doors tested in accordance with UL 1978 and rated for **500 deg F (260 deg C)** continuously, or **2000 deg F (1093 deg C)** for 30 minutes; with positive or negative duct pressure

- and complying with NFPA 96.
- 2. Construction: **[0.0625 inch (1.6 mm)]****[No. 16 MSG]****[Steel having a thickness not less than that required for the duct]****[Type 304]****[Type 316]** stainless steel inner shell and **[aluminized-steel]****[stainless steel]** outer cover with two handles.
- 3. Fasteners: Stainless steel bolts and wing nuts.
 - a. Ensure that bolts do not penetrate interior of duct space.
- 4. Maintenance Access Door Minimum Dimensions: **[7 by 7 inches (178 by 178 mm)]****<Insert dimensions>**.
- 5. Personnel Access Door Minimum Dimensions: **[22 by 20 inches (559 by 508 mm)]****[24 by 18 inches (610 by 458 mm)]****[24 by 24 inches (610 by 610 mm)]****<Insert dimensions>**.
- 6. Door Label: Mark door with uppercase lettering as follows: "ACCESS PANEL. DO NOT OBSTRUCT."

2.2 UL-LISTED, FACTORY-FABRICATED GREASE DUCT - DOUBLE-WALL, REDUCED CLEARANCE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following]****[provide products by one of the following]****[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Ampco Stacks; DuraVent]**
 - 2. **[DuraVent]**
 - 3. **[Jeremias Inc.]**
 - 4. **[Metal-Fab, Inc]**
 - 5. **[Schebler Co. (The)]**
 - 6. **[Security Chimneys; DuraVent]**
 - 7. **[Selkirk Corporation; DuraVent]**
 - 8. **[Van-Packer Co.]**
 - 9. **[Ventilation Direct]**
 - 10. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Ampco Stacks; DuraVent]**
 - 2. **[DuraVent]**
 - 3. **[Jeremias Inc.]**
 - 4. **[Metal-Fab, Inc]**
 - 5. **[Schebler Co. (The)]**
 - 6. **[Security Chimneys; DuraVent]**
 - 7. **[Selkirk Corporation; DuraVent]**
 - 8. **[Van-Packer Co.]**
 - 9. **[Ventilation Direct]**
 - 10. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated, UL-listed and -labeled, double-wall duct system tested in accordance with UL 1978 and rated for **500 deg F (260 deg C)** continuously, or **2000 deg F (1093 deg C)** for 30 minutes; with positive or negative duct pressure and complying with NFPA 96.
- D. Construction: Inner shell and outer jacket separated by at least a **[1-inch (25-mm)]****[2-inch (50-mm)]****[3-inch (75-mm)]****[4-inch (100-mm)]** annular space filled with high-temperature, ceramic-fiber insulation. This insulation thickness is to comply with **[2-inch (50-mm)]****[4-inch (100-mm)]****[6-inch (150-mm)]****<Insert clearance dimension to combustibles dimension>** clearance to combustibles.



1. Inner Shell: ASTM A666, [Type 304][Type 316] stainless steel.
 2. Outer Jacket: [Aluminized][ASTM A666 stainless] steel where concealed from occupied space. Stainless steel where exposed to occupied space.
- E. Gaskets and Flanges: Ensure that gaskets and sealing materials are rated at **1500 deg F (816 deg C)** minimum.
- F. Hood Connectors: Constructed from same material as grease duct with internal or external continuously welded or brazed joints.
- G. Accessories: Tees, elbows, increasers, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters, and drain fittings.
- H. Grease Duct Access Doors: Provide access doors where indicated and where necessary for cleaning and inspection of duct interior.
1. Description: Factory-fabricated, -listed, and -labeled, double-wall [personnel][and][maintenance] access doors tested in accordance with UL 1978 and rated for **500 deg F (260 deg C)** continuously, or **2000 deg F (1093 deg C)** for 30 minutes; with positive or negative duct pressure and complying with NFPA 96.
 2. Construction: [0.0625 inch (1.6 mm)][No. 16 MSG][Steel having a thickness not less than that required for the duct][Type 304][Type 316] stainless steel inner shell and [aluminized-steel][stainless steel] outer cover with two handles.
 3. Fasteners: Stainless steel bolts and wing nuts.
 - a. Ensure that bolts do not penetrate interior of duct space.
 4. Maintenance Access Door Minimum Dimensions: [7 by 7 inches (178 by 178 mm)]<Insert dimensions>.
 5. Personnel Access Door Minimum Dimensions: [22 by 20 inches (559 by 508 mm)][24 by 18 inches (610 by 458 mm)][24 by 24 inches (610 by 610 mm)]<Insert dimensions>.
 6. Door Label: Mark door with uppercase lettering as follows: "ACCESS PANEL. DO NOT OBSTRUCT."

2.3 UL-LISTED, FACTORY-FABRICATED GREASE DUCT - SINGLE WALL

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [Ampco Stacks; DuraVent]
 2. [DuraVent]
 3. [Jeremias Inc.]
 4. [Metal-Fab, Inc]
 5. [Schebler Co. (The)]
 6. [Security Chimneys; DuraVent]
 7. [Selkirk Corporation; DuraVent]
 8. [Van-Packer Co.]
 9. [Ventilation Direct]
 10. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Ampco Stacks; DuraVent]**
 2. **[DuraVent]**
 3. **[Jeremias Inc.]**
 4. **[Metal-Fab, Inc]**
 5. **[Schebler Co. (The)]**
 6. **[Security Chimneys; DuraVent]**
 7. **[Selkirk Corporation; DuraVent]**
 8. **[Van-Packer Co.]**
 9. **[Ventilation Direct]**
 10. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated, UL-listed and -labeled, single-wall duct system tested in accordance with UL 1978 and rated for **500 deg F (260 deg C)** continuously, or **2000 deg F (1093 deg C)** for 30 minutes; with positive or negative duct pressure and complying with NFPA 96.
- D. Construction: Wall constructed of ASTM A666, **[Type 304][Type 316]** stainless steel.
- E. Gaskets and Flanges: Ensure that gaskets and sealing materials are rated at **1500 deg F (816 deg C)** minimum.
- F. Hood Connectors: Constructed from same material as grease duct with internal or external continuously welded or brazed joints.
- G. Accessories: Tees, elbows, increasers, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters, and drain fittings.
- H. Grease Duct Access Doors: Provide access doors where indicated and where necessary for cleaning and inspection of duct interior.
1. Description: Factory-fabricated, -listed, and -labeled, **[personnel][and][maintenance]** access doors tested in accordance with UL 1978 and rated for **500 deg F (260 deg C)** continuously, or **2000 deg F (1093 deg C)** for 30 minutes; with positive or negative duct pressure and complying with NFPA 96.
 2. Construction: **[0.0625 inch (1.6 mm)][No. 16 MSG][Steel having a thickness not less than that required for the duct][Type 304][Type 316]** stainless steel inner shell and **[aluminized-steel][stainless steel]** outer cover with two handles.
 3. Fasteners: Stainless steel bolts and wing nuts.
 - a. Ensure that bolts do not penetrate interior of duct space.
 4. Maintenance Access Door Minimum Dimensions: **[7 by 7 inches (178 by 178 mm)]<Insert dimensions>**.
 5. Personnel Access Door Minimum Dimensions: **[22 by 20 inches (559 by 508 mm)][24 by 18 inches (610 by 458 mm)][24 by 24 inches (610 by 610 mm)]<Insert dimensions>**.
 6. Door Label: Mark door with uppercase lettering as follows: "ACCESS PANEL. DO NOT OBSTRUCT."



PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF LISTED KITCHEN VENTILATION SYSTEM EXHAUST DUCTS

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. Comply with requirements in Section 077200 "Roof Accessories."
- B. Coordinate connections to kitchen exhaust hoods with requirements in Section 233813 "Commercial-Kitchen Hoods."
- C. Coordinate connections to exhaust fans with requirements in Section 233400 "HVAC Fans."
- D. Coordinate firestopping where grease ducts penetrate fire separations with requirements in Section 078413 "Penetration Firestopping."
- E. Comply with all installation requirements of NFPA 96, all applicable codes, and authorities having jurisdiction.
- F. Comply with minimum clearances from combustibles and minimum termination heights in accordance with product listing or NFPA 96 and UL 2221, whichever is most stringent.
- G. Install airtight **[personnel][and][maintenance]** access doors where indicated.
- H. Seal between sections of grease exhaust ducts in accordance with manufacturer's written installation instructions; use sealants recommended in writing by manufacturer.
- I. Grease Duct Supports: Construct duct bracing and supports from noncombustible material.
 - 1. Design bracing and supports to carry static and seismic loads within stress limitations of **[the International Building Code][and][NFPA 96]<Insert code reference document>**.
 - 2. Ensure that bolts, screws, rivets, and other mechanical fasteners do not penetrate duct walls.
- J. Connections: Make grease duct connections in accordance with requirements of applicable codes and authorities having jurisdiction.
 - 1. Grease Duct to Exhaust Fan Connections: Connect grease ducts to inlet side of fan using flanges, gaskets, and bolts.
 - 2. Grease Duct to Hood Connections:
 - a. Make grease duct to hood joints connections using internal or external continuously welded or brazed joints.
 - b. Make watertight grease duct to hood joints connections using flanges, gaskets, and bolts.
- K. Support ducts at intervals recommended by manufacturer to support weight of ducts and accessories, without applying loading on kitchen hoods.



1. Securely attach supports and bracing to structure.
 2. Where grease ducts and access doors are large enough for service personnel to enter, provide sufficient structural support to accommodate additional load.
- L. Grease Duct Enclosures: Comply with requirements of all applicable codes and authorities having jurisdiction.
- M. Coordinate fire-rated enclosure construction with Section 092116.23 "Gypsum Board Shaft Wall Assemblies."
- N. Repair damage to adjacent materials caused by installation of listed kitchen ventilation system exhaust ducts.
- 3.3 FIELD QUALITY CONTROL
- A. Perform air leakage test [**in presence of Owner's Representative**]before concealment of any portion of grease duct system.

END OF SECTION 23 35 00 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 35 13 00	23 35 00 00	Listed Kitchen Ventilation System Exhaust Ducts
23 35 13 13	23 35 00 00	Listed Kitchen Ventilation System Exhaust Ducts
23 35 16 00	23 35 00 00	Listed Kitchen Ventilation System Exhaust Ducts
23 35 16 16	23 35 00 00	Listed Kitchen Ventilation System Exhaust Ducts
23 35 19 00	23 35 00 00	Listed Kitchen Ventilation System Exhaust Ducts



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 36 00 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bypass, single-duct air terminal units.
2. Modulating, single-duct air terminal units.
3. Parallel fan-powered air terminal units.
4. Series fan-powered air terminal units.
5. Dual-duct air terminal units.
6. Induction air terminal units.
7. Diffuser-type air terminal units.
8. Balancing terminal units.
9. Pressure-control terminal units.
10. Critical environment control valve.
11. Underfloor air distribution terminal units.
12. Exhaust single-duct terminal units.
13. DOAS, series, fan-powered air terminal units.
14. Casing liner.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.
2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
3. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For air terminal units.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Hangers and supports, including methods for duct and building attachment[, **seismic restraints**,] and vibration isolation.

D. Delegated Design Submittal: For vibration isolation[**and supports**,][, **and seismic restraints**] indicated to comply with performance requirements and design criteria, including analysis data[**signed and sealed by the qualified professional engineer responsible for their preparation**].



1. Materials, fabrication, assembly, and spacing of hangers and supports.
2. Design Calculations: Calculate requirements for selecting vibration isolators[, **supports**,][and **seismic restraints**].

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, indicating the items described in this Section, and coordinated with all building trades.
- B. Seismic Qualification Data: For air terminal units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.
 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Instructions for resetting minimum and maximum air volumes.
 - b. Instructions for adjusting software set points.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fan-Powered-Unit Filters: Furnish [**one**]<Insert number> spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a Qualified Electrical Testing Laboratory, and marked for intended location and application.
- B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating,

Ventilating, and Air Conditioning."

- D. Delegated Design: **[Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to]** design vibration isolation[, supports,][and seismic restraints], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- E. Seismic Performance: Air terminal units shall withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[and the unit will be fully operational after the seismic event]."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 BYPASS, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - 2. **[Carnes Company]**
 - 3. **[Carrier Global Corporation]**
 - 4. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - 5. **[METALAIRE, Inc]**
 - 6. **[Nailor Industries Inc]**
 - 7. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - 8. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - 9. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - 2. **[Carnes Company]**
 - 3. **[Carrier Global Corporation]**
 - 4. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - 5. **[METALAIRE, Inc]**
 - 6. **[Nailor Industries Inc]**
 - 7. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - 8. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - 9. **<Insert manufacturer's name>**
- C. Description: Pressure-dependent, diverting-damper assembly inside unit casing with control components inside a protective metal shroud. Configuration enables variable volume airflow to individual zones while bypassing the unneeded air to the ceiling plenum for recirculation.
- D. Casing: Minimum **[20-gauge-][22-gauge-]<Insert dimension>** thick galvanized steel.
 - 1. Casing Liner: Comply with requirements in "Casing Liner" Article below for **["Casing Liner, Fibrous Glass" Paragraph]["Casing Liner, Flexible Elastomeric" Paragraph][with**

"Antimicrobial Erosion-Resistant Coating" Subparagraph][with "Foil-Faced Liner" Subparagraph][with "Solid Metal Liner" Subparagraph][with "Perforated Metal Liner" Subparagraph][with "Specialty Liner" Subparagraph].

- E. Diverter Assembly:
 - 1. Damper, shaft, and heavy-duty self-lubricating bearings.
- F. Attenuator Section: Casing material and thickness matching associated air terminal unit casing. Provide **[absorptive][packless]** attenuator integral with the air terminal unit, with noise transmission loss performance as required in schedules on Drawings.
- G. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **[0.1 inch (2.5 mm)][0.08 inch (2.0 mm)]**. Include manual air vent and drain valve. Provide hydronic heating coils for air terminal units scheduled on Drawings.
- H. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware. Provide electric-resistance heating coils for air terminal units scheduled on Drawings.
 - 1. Stage(s): **[One][Two][Three]**.
 - 2. SCR controlled.
 - 3. Access door interlocked disconnect switch.
 - 4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
 - 5. Nickel chrome 80/20 heating elements.
 - 6. Airflow switch for proof of airflow.
 - 7. Fuses in terminal box for overcurrent protection (for coils of more than 48 A).
 - 8. Pneumatic-electric switches and relays.
 - 9. Magnetic contactor for each step of control (for three-phase coils).
- I. Electric Controls:
 - 1. Electric Damper Actuator: 24 V, **[spring-return open][spring-return closed][fail in last position][, with microswitch to enable heating control circuit]**.
 - 2. Electric Thermostat: Wall-mounted electric type with temperature display in Fahrenheit and Celsius, and space temperature set point.
 - 3. Air Volume Controls: Pressure-dependent volume controls with field-adjustable minimum and maximum position stops.
- J. Electronic Controls:
 - 1. Electronic Damper Actuator: 24 V, **[spring-return open][spring-return closed][capacitor-discharge-return open][capacitor-discharge-return closed][fail in last position]**.
 - 2. Electronic Thermostat: Wall-mounted electronic type with temperature display in Fahrenheit and Celsius, and space temperature set point.
 - 3. Electronic Air Volume Controls: Pressure-dependent volume controls with field-adjustable minimum and maximum position stops.
- K. Direct Digital Controls:
 - 1. Terminal Unit Controller: Pressure-independent, VAV controller and integrated actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to

minimum and maximum air volumes.

- a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
 3. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controller, actuators, and room sensors are to be furnished under Section 230923 "Direct Digital Control (DDC) System for HVAC."
- L. Control Sequence: See [Section 230993.11 "Sequence of Operation for HVAC"] [Drawings].

2.3 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 2. [Carnes Company]
 3. [Carrier Global Corporation]
 4. [ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]
 5. [Johnson Controls, Inc.]
 6. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 7. [METALAIRE, Inc]
 8. [Nailor Industries Inc]
 9. [Price Industries Limited]
 10. [Titus; brand of Johnson Controls International plc, Global Products]
 11. [Trane]
 12. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 13. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 2. [Carnes Company]
 3. [Carrier Global Corporation]
 4. [ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]
 5. [Johnson Controls, Inc.]
 6. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 7. [METALAIRE, Inc]
 8. [Nailor Industries Inc]
 9. [Price Industries Limited]
 10. [Titus; brand of Johnson Controls International plc, Global Products]
 11. [Trane]
 12. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 13. <Insert manufacturer's name>



- C. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- D. Casing: Minimum **[20-gauge-][22-gauge-]** thick galvanized steel.
 - 1. Casing Liner: Comply with requirements in "Casing Liner" Article below for **["Casing Liner, Fibrous Glass" Paragraph][“Casing Liner, Flexible Elastomeric” Paragraph][with “Antimicrobial Erosion-Resistant Coating” Subparagraph][with “Foil-Faced Liner” Subparagraph][with “Solid Metal Liner” Subparagraph][with “Perforated Metal Liner” Subparagraph][with “Specialty Liner” Subparagraph]**.
 - 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 - 3. Air Outlet: S-slip and drive connections[, **size matching inlet size**].
 - 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
- E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: AHRI 880 rated, **[1][2]** percent of nominal airflow at **[3-inch wg (750-Pa)]<Insert value>** inlet static pressure.
- F. Velocity Sensors: Multipoint array with velocity inlet sensors.
- G. Attenuator Section: Casing material and thickness matching associated air terminal unit casing. Provide **[absorptive][packless]** attenuator integral with the air terminal unit, with noise transmission loss performance as required in schedules on Drawings.
- H. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **[0.1 inch (2.5 mm)][0.08 inch (2.0 mm)]**. Include manual air vent and drain valve. Provide hydronic heating coils for air terminal units scheduled on Drawings.
- I. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware. Provide electric-resistance heating coils for air terminal units scheduled on Drawings.
 - 1. Stage(s): **[One][Two][Three]**.
 - 2. SCR controlled.
 - 3. Access door interlocked disconnect switch.
 - 4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
 - 5. Nickel chrome 80/20 heating elements.
 - 6. Airflow switch for proof of airflow.
 - 7. Fan interlock contacts.
 - 8. Fuses in terminal box for overcurrent protection (for coils of more than 48 A).
 - 9. Pneumatic-electric switches and relays.
 - 10. Magnetic contactor for each step of control (for three-phase coils).
- J. Electric Controls:
 - 1. Electric Damper Actuator: 24 V, **[spring-return open][spring-return closed][fail in last position]**.
 - 2. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
 - 3. Air Volume Controls: Pressure-dependent volume controls with field-adjustable minimum and

maximum position stops.

K. Electronic Controls:

1. Electronic Damper Actuator: 24 V, [spring-return open][spring-return closed][capacitor-discharge-return open][capacitor-discharge-return closed][fail in last position].
2. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
3. Electronic Air Volume Controller: Pressure-independent analog electronic controller, factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to electronic thermostat signal while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at air inlet.

L. Pneumatic Controls:

1. Pneumatic Damper Actuator: [0 to 13 psig (0 to 90 kPa)]<Insert range> spring range.
2. Pneumatic Thermostat: Wall-mounted pneumatic type [direct acting][and][reverse acting] with appropriate mounting hardware.
3. Pneumatic Air Volume Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to pneumatic thermostat signal while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at air inlet.

M. Direct Digital Controls:

1. Terminal Unit Controller: Pressure-independent, VAV controller and integrated actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Room Sensor: Wall mounted with [temperature set-point adjustment and]access for connection of portable operator terminal.
3. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controllers, integrated actuators, and room sensors to be furnished under Section 230923 "Direct Digital Controls (DDC) for HVAC."

- N. Control Sequence: See [Section 230993.11 "Sequence of Operation for HVAC"] [Drawings] for control sequences.

2.4 PARALLEL FAN-POWERED AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
2. [Carnes Company]
3. [Carrier Global Corporation]
4. [ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North

- America]
- 5. [Johnson Controls, Inc.]
- 6. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
- 7. [METALAIRES, Inc.]
- 8. [Nailor Industries Inc]
- 9. [Price Industries Limited]
- 10. [Titus; brand of Johnson Controls International plc, Global Products]
- 11. [Trane]
- 12. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
- 13. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- 1. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
- 2. [Carnes Company]
- 3. [Carrier Global Corporation]
- 4. [ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]
- 5. [Johnson Controls, Inc.]
- 6. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
- 7. [METALAIRES, Inc.]
- 8. [Nailor Industries Inc]
- 9. [Price Industries Limited]
- 10. [Titus; brand of Johnson Controls International plc, Global Products]
- 11. [Trane]
- 12. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
- 13. <Insert manufacturer's name>

C. Description: Volume-damper assembly and centrifugal fan in parallel arrangement inside unit casing with control components inside a protective metal shroud[; **low-profile design**].

D. Casing: Minimum [20-gauge-][22-gauge-] thick galvanized steel.

- 1. Casing Liner: Comply with requirements in "Casing Liner" Article below for ["Casing Liner, Fibrous Glass" Paragraph]["Casing Liner, Flexible Elastomeric" Paragraph][with "Antimicrobial Erosion-Resistant Coating" Subparagraph][with "Foil-Faced Liner" Subparagraph][with "Solid Metal Liner" Subparagraph][with "Perforated Metal Liner" Subparagraph][with "Specialty Liner" Subparagraph].
- 2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
- 3. Air Outlet: S-slip and drive connections.
- 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
- 5. Fan: Forward-curved centrifugal, located at plenum air inlet.

E. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.

- 1. Maximum Damper Leakage: AHRI 880 rated, [1][2] percent of nominal airflow at [3-inch wg (750-Pa)]<Insert value> inlet static pressure.

F. Velocity Sensors: Multipoint array with velocity inlet sensors.

G. Fan Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 2. Type: **[Permanent-split capacitor with SCR for speed adjustment][Electronically commutated motor]**.
 3. Fan-Motor Assembly Isolation: Rubber isolators.
 4. Enclosure: **[Open dripproof][Totally enclosed, fan cooled]<Insert type>**.
 5. Enclosure Materials: **[Cast iron]<Insert material>**.
 6. Motor Bearings: **<Insert requirements>**.
 7. Unusual Service Conditions:
 - a. Ambient Temperature: **<Insert deg F (deg C)>**.
 - b. Altitude: **<Insert feet (m)>** above sea level.
 - c. High humidity.
 - d. **<Insert conditions>**.
 8. Efficiency: Premium efficient as defined in NEMA MG-1.
 9. NEMA Design: **<Insert designation>**.
 10. Service Factor: **<Insert value>**.
 11. Motor Speed: **[Single speed][Variable speed]**.
 - a. Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.
 12. Electrical Characteristics:
 - a. Horsepower: **<Insert horsepower>**.
 - b. Volts: **[120][208][230][460]<Insert value>**.
 - c. Phase: **[Single][Poly]**.
 - d. Hertz: 60.
 - e. Full-Load Amperes: **<Insert value>**.
 - f. Minimum Circuit Ampacity: **<Insert value>**.
 - g. Maximum Overcurrent Protection: **<Insert amperage>**.
- H. Filters:
1. Polyurethane Foam: **[MERV 3]<Insert value>**. Minimum efficiency reporting value and average arrestance is in accordance with ASHRAE 52.2.
 2. **[Flat, Nonpleated][Pleated]** Glass Fiber: Factory-fabricated, self-supported disposable air filter with holding frames. Provide **[MERV 6][MERV 13]<Insert value>** filter with minimum efficiency reporting value is to be in accordance with ASHRAE 52.2.
- I. Attenuator Section: Casing material and thickness matching associated air terminal unit casing. Provide **[absorptive][packless]** attenuator integral with the **[plenum inlet][and][discharge outlet]** of the air terminal unit, of noise transmission loss performance as required in schedules on Drawings.
- J. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **[0.1 inch (2.5 mm)][0.08 inch (2.0 mm)]**. Include manual air vent and drain valve. Locate coil in **[plenum air inlet][discharge-air outlet]** airstream. Provide hydronic heating coils for air terminal units scheduled on Drawings.
- K. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware. Locate coil in discharge-air outlet airstream. Provide electric-resistance heating coils for air terminal units scheduled on Drawings.
1. Stage(s): **[One][Two][Three]**.

2. SCR controlled.
 3. Access door interlocked disconnect switch.
 4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
 5. Nickel chrome 80/20 heating elements.
 6. Airflow switch for proof of airflow.
 7. Fan interlock contacts.
 8. Fuses in terminal box for overcurrent protection (for coils of more than 48 A).
 9. Pneumatic-electric switches and relays.
 10. Magnetic contactor for each step of control (for three-phase coils).
- L. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
 2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs will match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized in accordance with NFPA 70.
 3. Disconnect Switch: Factory-mounted fuse type.
- M. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
- N. Electric Controls:
1. Electric Damper Actuator: 24 V, [**spring-return open**][**spring-return closed**][**fail in last position**].
 2. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
 3. Air Volume Controls: Pressure-dependent volume controls with field-adjustable minimum and maximum position stops.
- O. Electronic Controls:
1. Electronic Damper Actuator: 24 V, [**spring-return open**][**spring-return closed**][**capacitor-discharge-return open**][**capacitor-discharge-return closed**][**fail in last position**].
 2. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
 3. Electronic Air Volume Controller: Pressure-independent analog electronic controller, factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to electronic thermostat signal while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at air inlet.
- P. Pneumatic Controls:
1. Pneumatic Damper Actuator: [**0 to 13 psig (0 to 90 kPa)**]**<Insert range>** spring range.
 2. Pneumatic Thermostat: Wall-mounted pneumatic-type, [**direct acting**][**reverse acting**][**direct or reverse acting as indicated on Drawings**], with appropriate mounting hardware.
 3. Pneumatic Air Volume Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to pneumatic thermostat signal while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at air inlet.

Q. Direct Digital Controls:

1. Terminal Unit Controller: Pressure-independent, VAV controller with integrated actuator and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Room Sensor: Wall mounted with[**temperature set-point adjustment and**] access for connection of portable operator terminal.
3. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controllers, actuators, and room sensors are to be furnished under Section 230923 "Direct Digital Control (DDC) System for HVAC."

R. Control Sequence: See [**Section 230993.11 "Sequence of Operation for HVAC"**][**Drawings**] for control sequences.

2.5 SERIES FAN-POWERED AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

1. [**Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.**]
2. [**Carnes Company**]
3. [**Carrier Global Corporation**]
4. [**ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America**]
5. [**Johnson Controls, Inc.**]
6. [**Krueger-HVAC; brand of Johnson Controls International plc, Global Products**]
7. [**METALAIRE, Inc**]
8. [**Nailor Industries Inc**]
9. [**Price Industries Limited**]
10. [**Titus; brand of Johnson Controls International plc, Global Products**]
11. [**Trane**]
12. [**Tuttle & Bailey; brand of Johnson Controls International plc, Global Products**]
13. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [**Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.**]
2. [**Carnes Company**]
3. [**Carrier Global Corporation**]
4. [**ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America**]
5. [**Johnson Controls, Inc.**]
6. [**Krueger-HVAC; brand of Johnson Controls International plc, Global Products**]
7. [**METALAIRE, Inc**]
8. [**Nailor Industries Inc**]
9. [**Price Industries Limited**]

10. [Titus; brand of Johnson Controls International plc, Global Products]
 11. [Trane]
 12. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 13. <Insert manufacturer's name>
- C. Description: Volume-damper assembly and centrifugal fan in series arrangement inside unit casing with control components inside a protective metal shroud.
1. Designed for quiet operation.
 2. Low-profile design.
- D. Casing: Minimum [20-gauge-][22-gauge-] thick galvanized steel.
1. Casing Liner: Comply with requirements in "Casing Liner" Article below for ["Casing Liner, Fibrous Glass" Paragraph][**"Casing Liner, Flexible Elastomeric" Paragraph**][with **"Antimicrobial Erosion-Resistant Coating" Subparagraph**][with **"Foil-Faced Liner" Subparagraph**][with **"Solid Metal Liner" Subparagraph**][with **"Perforated Metal Liner" Subparagraph**][with **"Specialty Liner" Subparagraph**].
 2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
 3. Air Outlet: S-slip and drive connections.
 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
 5. Fan: Forward-curved centrifugal.
- E. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: AHRI 880 rated, [1][2] percent of nominal airflow at [3-inch wg (750-Pa)]<Insert value> inlet static pressure.
- F. Velocity Sensors: Multipoint array with velocity sensors in air inlet.
- G. Fan Motor:
1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 2. Type: [Permanent-split capacitor with SCR for speed adjustment][**Electronically commutated motor**].
 3. Fan-Motor Assembly Isolation: Rubber isolators.
 4. Enclosure: [Open dripproof][**Totally enclosed, fan cooled**]<Insert type>.
 5. Enclosure Materials: [Cast iron]<Insert material>.
 6. Motor Bearings: <Insert requirements>.
 7. Unusual Service Conditions:
 - a. Ambient Temperature: <Insert deg F (deg C)>.
 - b. Altitude: <Insert feet (m)> above sea level.
 - c. High humidity.
 - d. <Insert conditions>.
 8. Efficiency: Premium efficient as defined by NEMA MG-1.
 9. NEMA Design: <Insert designation>.
 10. Service Factor: <Insert value>.
 11. Motor Speed: [Single speed][Variable speed].
 - a. Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.

12. Electrical Characteristics:

- a. Horsepower: <Insert horsepower>.
- b. Volts: [120][208][230][460]<Insert value>.
- c. Phase: [Single][Poly].
- d. Hertz: 60.
- e. Full-Load Amperes: <Insert value>.
- f. Minimum Circuit Ampacity: <Insert value>.
- g. Maximum Overcurrent Protection: <Insert amperage>.

H. Filters:

1. Polyurethane Foam: [MERV 3]<Insert value>. Minimum efficiency reporting value and average arrestance in accordance with ASHRAE 52.2.
2. [Flat, Nonpleated][Pleated] Glass Fiber: Factory-fabricated, self-supported disposable air filter with holding frames. Provide [MERV 6][MERV 13]<Insert value> filters with minimum efficiency reporting value is to be in accordance with ASHRAE 522.

I. Attenuator Section: Casing material and thickness matching associated air terminal unit casing. Provide [absorptive][packless] attenuator integral with the [plenum inlet][and][discharge outlet] of the air terminal unit, of noise transmission loss performance as required in schedules on Drawings.

J. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than [0.1 inch (2.5 mm)][0.08 inch (2.0 mm)]. Include manual air vent and drain valve. Locate coil in discharge outlet airstream. Provide hydronic heating coils for air terminal units scheduled on Drawings.

K. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware. Locate coil in discharge outlet airstream. Provide electric-resistance heating coils for air terminal units scheduled on Drawings.

1. Stage(s): [One][Two][Three].
2. SCR controlled.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
5. Nickel chrome 80/20 heating elements.
6. Airflow switch for proof of airflow.
7. Fan interlock contacts.
8. Fuses in terminal box for overcurrent protection (for coils of more than 48 A).
9. Pneumatic-electric switches and relays.
10. Magnetic contactor for each step of control (for three-phase coils).

L. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized in accordance with NFPA 70.
3. Disconnect Switch: Factory-mounted fuse type.

M. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.



N. Electric Controls:

1. Electric Damper Actuator: 24 V, [**spring-return open**][**spring-return closed**][**fail in last position**].
2. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius[, **and space temperature set point**].
3. Air Volume Controls: Pressure-dependent volume controls with field-adjustable minimum and maximum position stops.

O. Electronic Controls:

1. Electronic Damper Actuator: 24 V, [**spring-return open**][**spring-return closed**][**capacitor-discharge-return open**][**capacitor-discharge-return closed**][**fail in last position**].
2. Electronic Thermostat: Wall-mounted electronic type with temperature display in Fahrenheit and Celsius.
3. Electronic Air Volume Controller: Pressure-independent analog electronic controller, factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to electronic thermostat signal while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at air inlet.

P. Pneumatic Controls:

1. Pneumatic Damper Actuator: **[0 to 13 psig (0 to 90 kPa)]**<Insert range> spring range.
2. Pneumatic Thermostat: Wall-mounted, pneumatic type, [**direct acting**][**and**][**reverse acting**], with appropriate mounting hardware.
3. Pneumatic Air Volume Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to pneumatic thermostat while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at air inlet.

Q. Direct Digital Controls:

1. Terminal Unit Controller: Pressure-independent, VAV controller and integrated actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Instrumentation and Control for HVAC."
2. Room Sensor: Wall mounted with[**temperature set-point adjustment and**] access for connection of portable operator terminal.
3. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal unit manufacturer; unit controller, actuators, and room sensors are to be furnished under Section 230923 "Direct Digital Control (DDC) for HVAC".

R. Control Sequence: See [**Section 230993.11 "Sequence of Operation for HVAC"**][**Drawings**] for control sequences.

2.6 DUAL-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 2. **[Carnes Company]**
 3. **[Carrier Global Corporation]**
 4. **[ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]**
 5. **[Johnson Controls, Inc.]**
 6. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 7. **[METALAIRE, Inc]**
 8. **[Nailor Industries Inc]**
 9. **[Price Industries Limited]**
 10. **[Titus; brand of Johnson Controls International plc, Global Products]**
 11. **[Trane]**
 12. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 13. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 2. **[Carnes Company]**
 3. **[Carrier Global Corporation]**
 4. **[ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]**
 5. **[Johnson Controls, Inc.]**
 6. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 7. **[METALAIRE, Inc]**
 8. **[Nailor Industries Inc]**
 9. **[Price Industries Limited]**
 10. **[Titus; brand of Johnson Controls International plc, Global Products]**
 11. **[Trane]**
 12. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 13. **<Insert manufacturer's name>**
- C. Description: **[Mixing][and][nonmixing]** with two volume dampers inside unit casing with mixing attenuator section and control components inside a protective metal shroud.
- D. Casing: Minimum **[20-gauge-][22-gauge-]** thick galvanized steel.
1. Casing Liner: Comply with requirements in "Casing Liner" Article below for **["Casing Liner, Fibrous Glass" Paragraph]["Casing Liner, Flexible Elastomeric" Paragraph][with "Antimicrobial Erosion-Resistant Coating" Subparagraph][with "Foil-Faced Liner" Subparagraph][with "Solid Metal Liner" Subparagraph][with "Perforated Metal Liner" Subparagraph][with "Specialty Liner" Subparagraph]**.
 2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
 3. Air Outlet: S-slip and drive connections.
 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
- E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, **<Insert number>** percent of nominal airflow at **[3-inch wg (750-Pa)]<Insert value>** inlet static pressure.
- F. Velocity Sensors: Multipoint array with velocity sensors in each air inlet and air outlet.
- G. Attenuator Section: Casing material and thicknesses matching associated air terminal unit casing. Provide **[absorptive][packless]** attenuator integral with the air terminal unit, of noise transmission loss performance as required in schedules on Drawings.
- H. Electric Controls:
1. Electric Damper Actuator, Hot Deck: 24 V, **[spring-return open][spring-return closed][fail in last position]**.
 2. Electric Damper Actuator, Cold Deck: 24 V, **[spring-return open][spring-return closed][fail in last position]**.
 3. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
 4. Air Volume Controls: Pressure-dependent volume controls with field-adjustable minimum and maximum position stops.
- I. Electronic Controls:
1. Electronic Damper Actuator, Hot Deck: 24 V, **[spring-return open][spring-return closed][capacitor-discharge-return open][capacitor-discharge-return closed][fail in last position]**.
 2. Electronic Damper Actuator, Cold Deck: 24 V, **[spring- return open][spring- return closed][capacitor- discharge- return open][capacitor- discharge- return closed][fail in last position]**.
 3. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
 4. Electronic Air Volume Controller: Pressure-independent analog electronic controller, factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to electronic thermostat signal while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at each air inlet.
- J. Pneumatic Controls:
1. Pneumatic Damper Actuator: **[0 to 13 psig (0 to 90 kPa)]<Insert range>** spring range.
 2. Pneumatic Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.
 3. Pneumatic Air Volume Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to pneumatic thermostat signal while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at each air inlet.
- K. Terminal Unit Controller: Pressure-independent, VAV controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
1. Occupied and unoccupied operating mode.
 2. Remote reset of airflow or temperature set points.
 3. Adjusting and monitoring with portable terminal.
 4. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- L. Room Sensor: Wall mounted with **[temperature set-point adjustment and]**access for connection of

portable operator terminal.

- M. Terminal Unit Controller, Section 230923: Controllers and actuators are to be factory mounted and wired by air terminal manufacturer; unit controller, actuators, and room sensors are to be furnished under Section 230923 "Direct Digital Control (DDC) System for HVAC."
- N. Control Sequence: See [Section 230993.11 "Sequence of Operation for HVAC"] [Drawings] for control sequences.

2.7 INDUCTION AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - 2. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - 3. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - 2. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - 3. <Insert manufacturer's name>
- C. Description: Primary volume-damper and venturi assembly inside unit casing with mechanical induction damper mounted on casing and control components inside a protective metal shroud.
- D. Casing: Minimum 22-gauge-thick galvanized steel.
 - 1. Casing Liner: Comply with requirements in "Casing Liner" Article below for ["Casing Liner, Fibrous Glass" Paragraph]["Casing Liner, Flexible Elastomeric" Paragraph][with "Antimicrobial Erosion-Resistant Coating" Subparagraph][with "Foil-Faced Liner" Subparagraph][with "Solid Metal Liner" Subparagraph][with "Perforated Metal Liner" Subparagraph][with "Specialty Liner" Subparagraph].
 - 2. Air Inlet: Round stub connection for duct attachment.
 - 3. Air Outlet: S-slip and drive connections[, size matching inlet size].
 - 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
 - 5. Fan: Forward-curved centrifugal.
- E. Primary Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: AHRI 880 rated, <Insert number> percent of nominal airflow at [3-inch wg (750-Pa)]<Insert value> inlet static pressure.
- F. Induction Damper: Galvanized-steel, multiblade assembly with self-lubricating bearings.
- G. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than [0.1 inch (2.5 mm)][0.08 inch (2.0 mm)]. Include manual air vent and drain valve. Provide hydronic heating coils for air terminal units scheduled on Drawings.
- H. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary

manual, reset thermal cutouts. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware. Provide electric-resistance heating coils for air terminal units scheduled on Drawings.

1. Stage(s): **[One][Two][Three]**.
2. SCR controlled.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
5. Nickel chrome 80/20 heating elements.
6. Airflow switch for proof of airflow.
7. Fan interlock contacts.
8. Fuses in terminal box for overcurrent protection (for coils of more than 48 A).
9. Pneumatic-electric switches and relays.
10. Magnetic contactor for each step of control (for three-phase coils).

I. Electric Controls:

1. Electric Damper Actuator: 24 V, **[spring-return open][spring-return closed][fail in last position]**.
2. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius[, **and space temperature set point**].
3. Air Volume Controls: Pressure-dependent volume controls with field-adjustable minimum and maximum position stops.

J. Electronic Controls:

1. Electronic Damper Actuator: 24 V, powered open, **[spring-return open][spring-return closed][capacitor-discharge-return open][capacitor-discharge-return closed][fail in last position]**.
2. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
3. Electronic Air Volume Controller: Pressure-independent analog electronic controller, factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to electronic thermostat signal while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at air inlet.

K. Pneumatic Controls:

1. Pneumatic Damper Actuator: **[0 to 13 psig (0 to 90 kPa)]<Insert range>** spring range.
2. Pneumatic Thermostat: Wall-mounted pneumatic type, **[direct acting][reverse acting][direct or reverse acting as indicated on Drawings]**, with appropriate mounting hardware.
3. Pneumatic Air Volume Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to pneumatic thermostat while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at air inlet.

L. Direct Digital Controls:

1. Terminal Unit Controller: Pressure-independent, VAV controller with integrated actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
 - a. Occupied and unoccupied operating mode.

- b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- 2. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
- 3. Terminal Unit Controller, Section 230923: Controller and actuators are to be factory mounted and wired by air terminal unit manufacturer; unit controller, actuator, and room sensors are to be furnished under Section 230923 "Direct Digital Control (DDC) System for HVAC."
- M. Control Sequence: See [Section 230993.11 "Sequence of Operation for HVAC"] [Drawings] for control sequences.

2.8 DIFFUSER-TYPE AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. [Acutherm; by Price]
 - 2. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - 3. [Carnes Company]
 - 4. [Jackson Systems, LLC]
 - 5. [Rickard Air Diffusion]
 - 6. [Titus; brand of Johnson Controls International plc, Global Products]
 - 7. [Warren Technology]
 - 8. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. [Acutherm; by Price]
 - 2. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - 3. [Carnes Company]
 - 4. [Jackson Systems, LLC]
 - 5. [Rickard Air Diffusion]
 - 6. [Titus; brand of Johnson Controls International plc, Global Products]
 - 7. [Warren Technology]
 - 8. <Insert manufacturer's name>
- C. Description: Volume-damper, diffuser, controller assembly[and inlet electric heater] and wall-mounted temperature-sensing device[with master-drone capability].
- D. Volume Damper: [Galvanized steel]<Insert material> with peripheral gasket and self-lubricating bearings.
- E. Diffuser: [Galvanized steel][Aluminum]<Insert material> with [white][powder coat][or][baked-enamel finish]<Insert color and finish>.
- F. Wall-Mounted Temperature Sensor/Controller:
 - 1. Digital display LCD wall-mounted controller.
 - 2. Intuitive user operation.
 - 3. Controller settings retained during power loss.

4. Communication Interface: **[BACnet][Modbus]<Insert protocol>** compatible for integration with building automation system.
5. Operational features:
 - a. Set-point indication.
 - b. Set-point adjustment.
 - c. Changeover temperature indication.
 - d. Changeover temperature set-point adjustment.
 - e. Minimum damper position adjustment for ventilation air.

G. Accessories:

1. Modular plenum-rated plug-in cables for interconnecting master-drone diffusers.
2. Blank-off panels.
3. Pressure-relief ring.
4. 24 V ac transformer/power supply for master-drone configurations.
5. Plenum-rated, plug-in, diffuser interconnection cables for master-drone configurations.
6. Diffuser back-pan insulation.
7. T-bar mounting frame.
8. Plaster ceiling frame.

H. Control Sequence: See **[Section 230993.11 "Sequence of Operation for HVAC"]****[Drawings]** for control sequences.

2.9 BALANCING TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Titus; brand of Johnson Controls International plc, Global Products]**
2. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Titus; brand of Johnson Controls International plc, Global Products]**
2. **<Insert manufacturer's name>**

C. Description: Manually operated volume-damper assembly with locking mechanism inside unit casing with multipoint, center-averaging velocity sensors**[for installation above a ceiling]**.

D. Casing: Minimum 22-gauge-thick galvanized steel.

1. Leakage: Maximum 2 percent of nominal airflow at **1.5-inch wg (375-Pa)** static pressure.
2. Air Inlet: Round stub connection for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Casing Liner: Comply with requirements in "Casing Liner" Article below for **["Casing Liner, Fibrous Glass" Paragraph]["Casing Liner, Flexible Elastomeric" Paragraph][with "Antimicrobial Erosion-Resistant Coating" Subparagraph][with "Foil-Faced Liner" Subparagraph][with "Solid Metal Liner" Subparagraph][with "Perforated Metal Liner" Subparagraph][with "Specialty Liner" Subparagraph]**.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, [2]<Insert number> percent of nominal airflow at [3-inch wg (750-Pa)]<Insert value> inlet static pressure.

2.10 PRESSURE-CONTROL TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [Carnes Company]
 2. [Price Industries Limited]
 3. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 1. [Carnes Company]
 2. [Price Industries Limited]
 3. <Insert manufacturer's name>
- C. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud, designed to regulate duct pressure via throttling to control discharge pressure in a variable volume system.
- D. Casing: Minimum 22-gauge-thick galvanized steel.
 1. Casing Liner: Comply with requirements in "Casing Liner" Article below for ["Casing Liner, Fibrous Glass" Paragraph][Casing Liner, Flexible Elastomeric" Paragraph][with "Antimicrobial Erosion-Resistant Coating" Subparagraph][with "Foil-Faced Liner" Subparagraph][with "Solid Metal Liner" Subparagraph][with "Perforated Metal Liner" Subparagraph][with "Specialty Liner" Subparagraph].
 2. Air Inlet: Round stub connection for duct attachment.
 3. Air Outlet: S-slip and drive connections.
 4. Access: Removable panels for access to diverting damper and other parts requiring service, adjustment, or maintenance; with airtight gasket.
 5. Damper Assembly: Damper, shaft, and heavy-duty self-lubricating bearings.
- E. Attenuator Section: Construction materials and thicknesses matching associated air terminal unit casing. Provide [absorptive][packless] attenuator integral with the air terminal unit, of noise transmission loss performance as required in schedules on Drawings.
- F. Direct Digital Controls:
 1. Terminal Unit Controller: Pressure-independent controller and integrated [spring-return open][spring-return closed][capacitor-discharge-return open][capacitor-discharge-return closed][fail-in-last-position] actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum discharge pressures.
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of discharge pressure set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 2. Discharge Static Pressure Sensor: Discharge static pressure sensor to maintain constant static



- pressure within **[5]<Insert number>** percent of set point.
3. Terminal Unit Controller and Discharge Static Pressure Sensor, Section 230923: Controller, actuator, and sensor to be factory mounted and wired by air terminal manufacturer; unit controller, actuator, and sensor are to be furnished under Section 230923 "Direct Digital Control (DDC) System for HVAC."

- G. Control Sequence: See **[Section 230993.11 "Sequence of Operation for HVAC"]****[Drawings]** for control sequences.

2.11 CRITICAL ENVIRONMENT CONTROL VALVE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following]****[provide products by one of the following]****[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
2. **[Phoenix Controls Corporation]**
3. **[Price Industries Limited]**
4. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
5. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
2. **[Phoenix Controls Corporation]**
3. **[Price Industries Limited]**
4. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
5. **<Insert manufacturer's name>**

- C. Description: Volume-damper or venturi assembly inside a unit casing with control components inside a protective metal shroud, for general exhaust applications or for exhaust applications where pressurization control via exhaust and supply airflow control is desired and airstream corrosion and contamination may be a concern.

- D. Casing:

1. Material: **[Type 304 stainless steel]****[or]****[Type 316 stainless steel]****[Minimum 22-gauge galvanized steel with phenolic coating]****<Insert material>**.

- E. **[Airflow Metering, Option: Calibrated shaft position with self-adjusting, spring-loaded cone.]**

- F. **[Sensors, Option: Multipoint,]****[Type 316 stainless steel]****<Insert material>****[, removable].**

- G. Direct Digital Controls:

1. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controller, actuators, and room sensors are to be furnished under Section 230923 "Direct Digital Control (DDC) System for HVAC."

- H. Control Sequence: See **[Section 230993.11 "Sequence of Operation for HVAC"]****[Drawings]** for control sequences.

2.12 UNDERFLOOR AIR DISTRIBUTION TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Carrier Global Corporation]**
 2. **[Johnson Controls, Inc.]**
 3. **[Nailor Industries Inc]**
 4. **[Price Industries Limited]**
 5. **[Titus; brand of Johnson Controls International plc, Global Products]**
 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Carrier Global Corporation]**
 2. **[Johnson Controls, Inc.]**
 3. **[Nailor Industries Inc]**
 4. **[Price Industries Limited]**
 5. **[Titus; brand of Johnson Controls International plc, Global Products]**
 6. **<Insert manufacturer's name>**
- C. Description: Volume-damper assembly and fan in series arrangement inside low-profile unit casing with control components inside a protective metal shroud within a raised access floor. Design configuration for **[pressurized floor cavity supply][and][ducted air supply]**.
- D. Casing: Minimum **[20-gauge-][22-gauge-]** thick galvanized steel.
1. Integral floor discharge diffusers.
 2. Mixing damper.
 3. VAV throttling damper.
 4. Leveling feet.
 5. Casing Liner: Comply with requirements in "Casing Liner" Article below for **["Casing Liner, Fibrous Glass" Paragraph]["Casing Liner, Flexible Elastomeric" Paragraph][with "Antimicrobial Erosion-Resistant Coating" Subparagraph][with "Foil-Faced Liner" Subparagraph][with "Solid Metal Liner" Subparagraph][with "Perforated Metal Liner" Subparagraph][with "Specialty Liner" Subparagraph]**.
 6. Air Outlet: S-slip and drive connections.
 7. Access: Removable panels on top of casing, for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
 8. Fan: Forward-curved centrifugal **[in double blower configuration][with double blowers as scheduled]**.
- E. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: AHRI 880 rated, **[1][2]** percent of nominal airflow at **[3-inch wg (750-Pa)]<Insert value>** inlet static pressure.
 2. Damper Position: Normally **[open][closed]**.
- F. Velocity Sensors: Multipoint array with velocity sensors in air inlets.
- G. Motor:
1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements

- for motors specified in Section 230500 "Common Work Results for HVAC."
2. Type: **[Permanent-split capacitor with SCR for speed adjustment][Electronically commutated motor]**.
3. Fan-Motor Assembly Isolation: Rubber isolators.
4. Enclosure: **[Open dripproof][Totally enclosed, fan cooled]<Insert type>**.
5. Enclosure Materials: **[Cast iron]<Insert material>**.
6. Motor Bearings: **<Insert requirements>**.
7. Unusual Service Conditions:
 - a. Ambient Temperature: **<Insert deg F (deg C)>**.
 - b. Altitude: **<Insert feet (m)>** above sea level.
 - c. High humidity.
 - d. **<Insert conditions>**.
8. Efficiency: Premium efficient.
9. NEMA Design: **<Insert designation>**.
10. Service Factor: **<Insert value>**.
11. Motor Speed: **[Single speed][Variable speed]**.
12. Electrical Characteristics:
 - a. Horsepower: **<Insert horsepower>**.
 - b. Volts: **[120][208][230][460]<Insert value>**.
 - c. Phase: **[Single][Poly]**.
 - d. Hertz: 60.
 - e. Full-Load Amperes: **<Insert value>**.
 - f. Minimum Circuit Ampacity: **<Insert value>**.
 - g. Maximum Overcurrent Protection: **<Insert amperage>**.
- H. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **[0.1 inch (2.5 mm)][0.08 inch (2.0 mm)]**. Include manual air vent and drain valve. Locate coil in discharge outlet airstream. Provide hydronic heating coils for air terminal units scheduled on Drawings.
- I. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware. Locate coil in discharge outlet airstream. Provide electric-resistance heating coils for air terminal units scheduled on Drawings.
 1. Stage(s): **[One][Two][Three]**.
 2. SCR controlled.
 3. Access door interlocked disconnect switch.
 4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
 5. Nickel chrome 80/20 heating elements.
 6. Airflow switch for proof of airflow.
 7. Fan interlock contacts.
 8. Fuses in terminal box for overcurrent protection (for coils of more than 48 A).
 9. Pneumatic-electric switches and relays.
 10. Magnetic contactor for each step of control (for three-phase coils).
- J. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
 1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.

2. Wiring Terminations: Fan and controls to terminal strip. Verify terminal lugs match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized in accordance with NFPA 70.
 3. Disconnect Switch: Factory-mounted fuse type.
- K. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
- L. Electronic Controls:
1. Electronic Damper Actuator: 24 V, **[spring-return open][spring-return closed][capacitor-discharge-return open][capacitor-discharge-return closed][fail in last position]**.
 2. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
 3. Electronic Air Volume Controller: Pressure-independent analog electronic controller, factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to electronic thermostat signal while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at air inlet.
- M. Direct Digital Controls:
1. Terminal Unit Controller: Pressure-independent, VAV controller with integrated actuator and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 2. Room Sensor: Set-point adjustment and access for connection of portable operator terminal.
 3. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controller, actuators, and room sensors are to be furnished under Section 230923 "Direct Digital Control (DDC) System for HVAC."
- N. Control Sequence: See **[Section 230993.11 "Sequence of Operation for HVAC"]****[Drawings]** for control sequences.
- 2.13 EXHAUST SINGLE-DUCT TERMINAL UNITS
- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 2. **[Nailor Industries Inc]**
 3. **[Price Industries Limited]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**

2. **[Nailor Industries Inc]**
 3. **[Price Industries Limited]**
 4. **<Insert manufacturer's name>**
- C. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud, for exhaust applications where pressurization control via exhaust and supply airflow control is desired.
- D. Casing: Minimum **[22-gauge-][20-gauge-]<Insert value>** thick galvanized steel.
1. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 2. Air Outlet: S-slip and drive connections[, **size matching inlet size**].
 3. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
- E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: AHRI 880 rated, **[1][2]** percent of nominal airflow at **[3-inch wg (750-Pa)]<Insert value>** inlet static pressure.
- F. Attenuator Section: Casing material and thickness matching associated air terminal unit casing. Provide **[absorptive][packless]** attenuator integral with the air terminal unit, of noise transmission loss performance as required in schedules on Drawings.
- G. Electric Controls:
1. Damper Actuator: 24 V, **[spring-return open][spring-return closed][fail in last position]**.
 2. Air Volume Controls: Pressure-dependent volume controls with field-adjustable minimum and maximum position stops.
 3. Differential Pressure Sensor: Wall-mounted type with set point.
- H. Electronic Controls:
1. Damper Actuator: 24 V, **[spring-return open][spring-return closed][capacitor-discharge-return open][capacitor-discharge-return closed][fail in last position]**.
 2. Electronic Air Volume Controller: Pressure-independent analog electronic controller, factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to electronic thermostat signal while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at air inlet.
 3. Differential Pressure Sensor: Wall-mounted electronic type with set-point display.
- I. Direct Digital Controls:
1. Terminal Unit Controller: Pressure-independent, controller and integrated **[spring-return open][spring-return closed][capacitor-discharge open][capacitor-discharge-return closed][fail-in-last-position]** actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

2. Room Sensor: Wall mounted with differential pressure set-point adjustment[**and access for connection of portable operator terminal**].
 3. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controller, actuators, and room sensors are to be furnished under Section 230923 "Direct Digital Control (DDC) System for HVAC."
 4. Damper Actuator: 24 V, [spring-return open][spring-return closed][capacitor-discharge-return open][capacitor-discharge-return closed][fail in last position].
- J. Control Sequence: See [Section 230993.11 "Sequence of Operation for HVAC"] [Drawings] for control sequences.
- 2.14 DOAS, SERIES, FAN-POWERED AIR TERMINAL UNITS
- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [Johnson Controls, Inc.]
 2. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 3. [Nailor Industries Inc]
 4. [Price Industries Limited]
 5. [Titus; brand of Johnson Controls International plc, Global Products]
 6. [Trane]
 7. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Johnson Controls, Inc.]
 2. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 3. [Nailor Industries Inc]
 4. [Price Industries Limited]
 5. [Titus; brand of Johnson Controls International plc, Global Products]
 6. [Trane]
 7. <Insert manufacturer's name>
- C. Description: Primary outside-air volume-damper assembly and fan in series arrangement inside unit casing, with control components inside a protective metal shroud, with chilled-water coil for sensible cooling.
- D. Casing: Minimum [20-gauge-][22-gauge-] thick galvanized steel.
1. Casing Liner: Comply with requirements in "Casing Liner" Article below for ["Casing Liner, Fibrous Glass" Paragraph]["Casing Liner, Flexible Elastomeric" Paragraph][with "Antimicrobial Erosion-Resistant Coating" Subparagraph][with "Foil-Faced Liner" Subparagraph][with "Solid Metal Liner" Subparagraph][with "Perforated Metal Liner" Subparagraph][with "Specialty Liner" Subparagraph].
 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 3. Air Outlet: S-slip and drive connections[, size matching inlet size].
 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
- E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: AHRI 880 rated, [1][2] percent of nominal airflow at [3-inch wg (750-

Pa)]<Insert value> inlet static pressure.

F. Velocity Sensors: Multipoint array with velocity inlet sensors.

G. Fan Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
2. Type: **[Permanent-split capacitor with SCR for speed adjustment][Electronically commutated motor]**.
3. Fan-Motor Assembly Isolation: Rubber isolators.
4. Enclosure: **[Open dripproof][Totally enclosed, fan cooled]<Insert type>**.
5. Enclosure Materials: **[Cast iron]<Insert material>**.
6. Motor Bearings: **<Insert requirements>**.
7. Unusual Service Conditions:
 - a. Ambient Temperature: **<Insert deg F (deg C)>**.
 - b. Altitude: **<Insert feet (m)>** above sea level.
 - c. High humidity.
 - d. **<Insert conditions>**.
8. Efficiency: Premium efficient as defined in NEMA MG-1.
9. NEMA Design: **<Insert designation>**.
10. Service Factor: **<Insert value>**.
11. Motor Speed: **[Single speed][Variable speed]**.
 - a. Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.
12. Electrical Characteristics:
 - a. Horsepower: **<Insert horsepower>**.
 - b. Volts: **[120][208][230][460]<Insert value>**.
 - c. Phase: **[Single][Poly]**.
 - d. Hertz: 60.
 - e. Full-Load Amperes: **<Insert value>**.
 - f. Minimum Circuit Ampacity: **<Insert value>**.
 - g. Maximum Overcurrent Protection: **<Insert amperage>**.

H. Filters:

1. Polyurethane Foam: **[MERV 3]<Insert value>**. Minimum efficiency reporting value and average arrestance in accordance with ASHRAE 52.2.
2. **[Flat, Nonpleated][Pleated]** Glass Fiber: Factory-fabricated, self-supported disposable air filter with holding frames. Provide **[MERV 6][MERV 13]<Insert value>** filter with minimum efficiency reporting value in accordance with ASHRAE 52.2.

I. Attenuator Section: Casing material and thickness matching associated air terminal unit casing. Provide **[absorptive][packless]** attenuator integral with the air terminal unit, of noise transmission loss performance as required in schedules on Drawings.

J. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **[0.1 inch (2.5 mm)][0.08 inch (2.0 mm)]**. Include manual air vent and drain valve. Provide hydronic heating coils for air terminal units scheduled on Drawings.

K. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum,

mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware. Provide electric-resistance heating coils for air terminal units scheduled on Drawings.

1. Stage(s): **[One][Two][Three]**.
 2. SCR controlled.
 3. Access door interlocked disconnect switch.
 4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
 5. Nickel chrome 80/20 heating elements.
 6. Airflow switch for proof of airflow.
 7. Fan interlock contacts.
 8. Fuses in terminal box for overcurrent protection (for coils of more than 48 A).
 9. Pneumatic-electric switches and relays.
 10. Magnetic contactor for each step of control (for three-phase coils).
- L. Hydronic Cooling Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **[0.1 inch (2.5 mm)][0.08 inch (2.0 mm)]**. Include manual air vent and drain valve. Locate cooling coils at plenum air inlet. Include galvanized-steel factory-installed drip tray **[and moisture sensor]**for safety in cases where cooling coil temporarily experiences nondesign conditions.
- M. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
 2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized in accordance with NFPA 70.
 3. Disconnect Switch: Factory-mounted fuse type.
- N. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
- O. Electric Controls:
1. Electric Damper Actuator: 24 V, **[spring-return open][spring-return closed][fail in last position]**.
 2. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
 3. Air Volume Controls: Pressure-dependent volume controls with field-adjustable minimum and maximum position stops.
- P. Electronic Controls:
1. Electronic Damper Actuator: 24 V, **[spring-return open][spring-return closed][capacitor-discharge-return open][capacitor-discharge-return closed][fail in last position]**.
 2. Electronic Thermostat: Wall-mounted electronic type with temperature display in Fahrenheit and Celsius.
 3. Electronic Air Volume Controller: Pressure-independent analog electronic controller, factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to electronic thermostat signal while compensating for inlet static-pressure variations of up to **4 inches wg (1000 Pa)**; includes a multipoint velocity sensor at air inlet.

Q. Pneumatic Controls:

1. Pneumatic Damper Actuator: [0 to 13 psig (0 to 90 kPa)]<Insert range> spring range.
2. Pneumatic Thermostat: Wall-mounted, pneumatic type, [direct acting][and][reverse acting], with appropriate mounting hardware.
3. Pneumatic Air Volume Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to pneumatic thermostat signal while compensating for inlet static-pressure variations of up to 4 inches wg (1000 Pa); includes a multipoint velocity sensor at air inlet.

R. Direct Digital Controls:

1. Terminal Unit Controller: Pressure-independent, VAV controller with integrated actuator and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
3. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controller, actuators, and room sensors are to be furnished under Section 230923 "Direct Digital Control (DDC) System for HVAC."
4. Cooling Coil Drip Pan Sensor: Shuts off fan upon detection of moisture in drip pan.

S. Control Sequence: See [Section 230993.11 "Sequence of Operation for HVAC"] [Drawings] for control sequences.

2.15 CASING LINER

A. Casing Liner, Fibrous Glass: Fibrous-glass duct liner, complying with ASTM C1071, NFPA 90A or NFPA 90B, and with NAIMA AH124.

1. Minimum Thickness: [1/2 inch (13 mm)][3/4 inch (19 mm)][1 inch (25 mm)].
 - a. Maximum Thermal Conductivity:
 - 1) Type I, Flexible: [0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)]<Insert value> at 75 deg F (24 deg C) mean temperature.
 - 2) Type II, Rigid: [0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K)]<Insert value> at 75 deg F (24 deg C) mean temperature.
2. Antimicrobial Erosion-Resistant Coating: Apply to surface of liner that will form interior surface of duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound is to be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Foil-Faced Liner: Minimum 0.001-inch (0.03-mm) reinforced, nonporous aluminum foil applied to matted insulation airstream face. [Encapsulate all insulation edges with sheet metal angles and channels, or tape.]
4. Solid Metal Liner: Solid [galvanized sheet metal]<Insert material> encapsulating matted insulation face from airstream.

5. Perforated Metal Liner: Perforated **[galvanized sheet metal]**<Insert material> encapsulating matted insulation face from airstream.
 6. Specialty Liner: <Insert specialty liner in coordination with manufacturers>.
 7. **[Solvent][Water]**-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.
 - a. Adhesive shall have a VOC content of 80 g/L or less.
 - b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - c. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - d. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - e. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - f. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- B. Casing Liner, Flexible Elastomeric: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
1. Minimum Thickness: **[1/2 inch (13 mm)]**<Insert dimension>.
 2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
 3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - a. Adhesive shall have a VOC content of 80 g/L or less.
 - b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - c. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - d. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - e. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - f. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.



2.16 SOURCE QUALITY CONTROL

- A. **[AHRI 880 Certification: Test, rate, and label assembled air terminal units in accordance with AHRI 880.]**
- B. **[AHRI 880: Test and rate assembled air terminal units in accordance with AHRI 880.]**
- C. Water Coils: Factory pressure test to **300 psig (2070 kPa)** in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 233113 "Metal Ducts" for hangers and supports.
- B. Install air terminal units according to NFPA 90A.
- C. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
- D. Install wall-mounted thermostats.

3.2 PIPING CONNECTIONS

- A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.
- B. Hot-Water **[and][Chilled-Water]** Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties," and connect heating **[and][cooling]** coils to supply piping with shutoff valve, strainer, control valve, and union or flange; and to return piping with balancing valve and union or flange.

3.3 DUCTWORK CONNECTIONS

- A. Comply with requirements in **[Section 233113 "Metal Ducts"]****[Section 233116 "Nonmetal Ducts"]** for connecting ducts to air terminal units.
- B. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.4 ELECTRICAL CONNECTIONS

- A. Install field power to each air terminal unit electrical power connection. Coordinate with air terminal unit manufacturer and installers.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert dimension> high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 IDENTIFICATION

- A. Label each air terminal unit with drawing designation, nominal airflow, maximum and minimum factory-set airflows[, and coil type]. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - 3. Verify that controls and control enclosure are accessible.
 - 4. Verify that control connections are complete.
 - 5. Verify that nameplate and identification tag are visible.
 - 6. Verify that controls respond to inputs as specified.
 - 7. **<Insert startup steps if any>.**

3.8 ADJUSTING

- A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air terminal unit testing, adjusting, and balancing.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner][Contractor]** will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.



- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Air terminal unit will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 23 36 00 00



SECTION 23 36 13 00 - REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Registers - adjustable-blade face.
2. Registers - fixed-blade face.
3. Grilles - adjustable-blade face.
4. Grilles - fixed-blade face.
5. Grilles - linear bar.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
2. Section 233713.13 "Air Diffusers" for various types of air diffusers.
3. Section 233713.43 "Security Registers and Grilles" for security registers and security grilles.
4. Section 233716 "Fabric Air-Diffusion Devices" for continuous tubular diffusers.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - b. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified. Smallest size register and grille indicated.

C. Samples for Initial Selection: For registers and grilles with factory-applied color finishes. Actual size of smallest register and grille indicated.

D. Samples for Verification: For registers and grilles, in manufacturer's standard sizes to verify color selected. Actual size of smallest size register and grille indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.



4. Ceiling-mounted items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 REGISTERS

A. Registers - Adjustable-Blade Face :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Dayus Register & Grille Inc.]**
 - e. **[Hart & Cooley, LLC]**
 - f. **[Kees, Inc]**
 - g. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - h. **[METALAIRE, Inc]**
 - i. **[Nailor Industries Inc]**
 - j. **[Price Industries Limited]**
 - k. **[Raymon Company]**
 - l. **[Shoemaker Mfg. Co.]**
 - m. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - n. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - o. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Dayus Register & Grille Inc.]**
 - e. **[Hart & Cooley, LLC]**
 - f. **[Kees, Inc]**
 - g. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - h. **[METALAIRE, Inc]**
 - i. **[Nailor Industries Inc]**
 - j. **[Price Industries Limited]**
 - k. **[Raymon Company]**
 - l. **[Shoemaker Mfg. Co.]**
 - m. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - n. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - o. **<Insert manufacturer's name>**

3. Material: **[Steel][Aluminum][Stainless steel]**.
4. Finish: **[Baked enamel, white][Baked enamel, color selected by Architect][Clear anodized]<Insert finish>**.
5. Face-Blade Arrangement: Face blades with adjustable angle to permit manual adjustment of air discharge direction. Blades **[horizontally][vertically]** spaced **[3 inches (76 mm)][1-1/2 inches (38 mm)][3/4 inch (19 mm)][1/2 inch (13 mm)]<Insert dimension>** apart.
6. Core Construction: **[Integral][Removable]**.
7. Rear-Blade Arrangement: Rear blades with adjustable angle to permit manual adjustment of air discharge direction. Blades **[horizontally][vertically]** spaced **[3/4 inch (19 mm)][1/2 inch (13 mm)]<Insert dimension>** apart.
8. Frame: **[1-1/4 inches (32 mm)][1 inch (25 mm)]<Insert dimension>** wide.
9. Filter-Mounting Frame: **<Insert frame size and style>**.
10. Mounting: **[Countersunk screw][Concealed][Lay in]**.
11. Accessories:
 - a. Damper Type: **[Multishutter][Adjustable opposed blade][NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C)]**.
 - b. **[Front][Rear]**-blade gang operator.
 - c. Filter.

B. Registers - Fixed-Blade Face :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Dayus Register & Grille Inc.]**
 - e. **[Hart & Cooley, LLC]**
 - f. **[Kees, Inc]**
 - g. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - h. **[METALAIRE, Inc]**
 - i. **[Nailor Industries Inc]**
 - j. **[Price Industries Limited]**
 - k. **[Raymon Company]**
 - l. **[Shoemaker Mfg. Co.]**
 - m. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - n. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - o. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Dayus Register & Grille Inc.]**
 - e. **[Hart & Cooley, LLC]**
 - f. **[Kees, Inc]**
 - g. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - h. **[METALAIRE, Inc]**
 - i. **[Nailor Industries Inc]**

- j. [Price Industries Limited]
 - k. [Raymon Company]
 - l. [Shoemaker Mfg. Co.]
 - m. [Titus; brand of Johnson Controls International plc, Global Products]
 - n. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - o. <Insert manufacturer's name>
- 3. Material: [Steel][Aluminum][Stainless steel].
 - 4. Finish: [Baked enamel, white][Baked enamel, color selected by Architect][Clear anodized]<Insert finish>.
 - 5. Face-Blade Arrangement: Fixed-position face blades, [horizontally][vertically] spaced [3/4 inch (19 mm)][1/2 inch (13 mm)]<Insert dimension> apart.
 - 6. Core Construction: [Integral][Removable].
 - 7. Frame: [1-1/4 inches (32 mm)][1 inch (25 mm)]<Insert dimension> wide.
 - 8. Filter-Mounting Frame: <Insert frame size and style>.
 - 9. Mounting: [Countersunk screw][Concealed][Lay in].
 - 10. Damper Type: [Multishutter][Adjustable opposed blade][NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C)].
 - 11. Accessory: Filter.

2.2 GRILLES

A. Grilles - Adjustable-Blade Face :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [A-J Manufacturing Co., Inc]
 - b. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - c. [Carnes Company]
 - d. [Dayus Register & Grille Inc.]
 - e. [Hart & Cooley, LLC]
 - f. [Kees, Inc]
 - g. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 - h. [METALAIRE, Inc]
 - i. [Nailor Industries Inc]
 - j. [Price Industries Limited]
 - k. [Raymon Company]
 - l. [Shoemaker Mfg. Co.]
 - m. [Titus; brand of Johnson Controls International plc, Global Products]
 - n. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - o. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [A-J Manufacturing Co., Inc]
 - b. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - c. [Carnes Company]
 - d. [Dayus Register & Grille Inc.]
 - e. [Hart & Cooley, LLC]

- f. **[Kees, Inc]**
 - g. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - h. **[METALAIRE, Inc]**
 - i. **[Nailor Industries Inc]**
 - j. **[Price Industries Limited]**
 - k. **[Raymon Company]**
 - l. **[Shoemaker Mfg. Co.]**
 - m. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - n. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - o. **<Insert manufacturer's name>**
- 3. Material: **[Steel][Aluminum][Stainless steel]**.
 - 4. Finish: **[Baked enamel, white][Baked enamel, color selected by Architect][Clear anodized]<Insert finish>**.
 - 5. Face-Blade Arrangement: Face blades with adjustable angle to permit manual adjustment of discharge direction. Blades **[horizontally][vertically]** spaced **[3 inches (76 mm)][1-1/2 inches (38 mm)][3/4 inch (19 mm)][1/2 inch (13 mm)]<Insert dimension>** apart.
 - 6. Core Construction: **[Integral][Removable]**.
 - 7. Rear-Blade Arrangement: All rear blades with adjustable angle to permit manual adjustment of air-discharge direction. Blades **[horizontally][vertically]** spaced **[3/4 inch (19 mm)][1/2 inch (13 mm)]<Insert dimension>** apart.
 - 8. Frame: **[1-1/4 inches (32 mm)][1 inch (25 mm)]<Insert dimension>** wide.
 - 9. Filter-Mounting Frame: **<Insert frame size and style>**.
 - 10. Mounting: **[Countersunk screw][Concealed][Lay in]**.
 - 11. Accessories:
 - a. Damper: Opposed blade, spring closing, and with NRTL listed fusible link for **160 deg F (71 deg C)**.
 - b. **[Front][Rear]**-blade gang operator.
 - c. Filter.

B. Grilles - Fixed-Blade Face :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Dayus Register & Grille Inc.]**
 - e. **[Hart & Cooley, LLC]**
 - f. **[Kees, Inc]**
 - g. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - h. **[METALAIRE, Inc]**
 - i. **[Nailor Industries Inc]**
 - j. **[Price Industries Limited]**
 - k. **[Raymon Company]**
 - l. **[Shoemaker Mfg. Co.]**
 - m. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - n. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - o. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. [A-J Manufacturing Co., Inc]
 - b. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - c. [Carnes Company]
 - d. [Dayus Register & Grille Inc.]
 - e. [Hart & Cooley, LLC]
 - f. [Kees, Inc]
 - g. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 - h. [METALAIRE, Inc]
 - i. [Nailor Industries Inc]
 - j. [Price Industries Limited]
 - k. [Raymon Company]
 - l. [Shoemaker Mfg. Co.]
 - m. [Titus; brand of Johnson Controls International plc, Global Products]
 - n. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - o. <Insert manufacturer's name>
3. Material: [Steel][Aluminum][Stainless steel].
 4. Finish: [Baked enamel, white][Baked enamel, color selected by Architect]<Insert finish>.
 5. Face-Blade Arrangement: Fixed-face blade position, [horizontally][vertically] spaced [3/4 inch (19 mm)][1/2 inch (13 mm)]<Insert dimension> apart.
 6. Core Construction: [Integral][Removable].
 7. Frame: [1-1/4 inches (32 mm)][1 inch (25 mm)]<Insert dimension> wide.
 8. Filter-Mounting Frame: <Insert frame size and style>.
 9. Mounting: [Countersunk screw][Concealed][Lay in].
 10. Accessory: Filter.

C. Grilles - Linear Bar :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [A-J Manufacturing Co., Inc]
 - b. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - c. [Carnes Company]
 - d. [Dayus Register & Grille Inc.]
 - e. [Hart & Cooley, LLC]
 - f. [Kees, Inc]
 - g. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 - h. [METALAIRE, Inc]
 - i. [Nailor Industries Inc]
 - j. [Price Industries Limited]
 - k. [Raymon Company]
 - l. [Shoemaker Mfg. Co.]
 - m. [Titus; brand of Johnson Controls International plc, Global Products]
 - n. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - o. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [A-J Manufacturing Co., Inc]
 - b. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - c. [Carnes Company]
 - d. [Dayus Register & Grille Inc.]
 - e. [Hart & Cooley, LLC]
 - f. [Kees, Inc]
 - g. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 - h. [METALAIRE, Inc]
 - i. [Nailor Industries Inc]
 - j. [Price Industries Limited]
 - k. [Raymon Company]
 - l. [Shoemaker Mfg. Co.]
 - m. [Titus; brand of Johnson Controls International plc, Global Products]
 - n. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - o. <Insert manufacturer's name>
3. Material: [Steel][Stainless steel][Aluminum].
 4. Finish: [Baked enamel, white][Clear anodized][Baked enamel, color selected by Architect]<Insert finish>.
 5. Face-Blade Arrangement:
 - a. Blade width: [1/8 inch (3 mm)][1/4 inch (6 mm)]
 - b. Blade spacing: [1/4 inch (6 mm)][1/2 inch (13 mm)][7/16 inch (11 mm)].
 - c. Fixed [0][15][30]-degree discharge angle.
 6. Core Construction: [Integral][Removable].
 7. Distribution plenum.
 - a. Internal insulation.
 - b. Inlet damper.
 8. Frame: [1-1/4 inches (32 mm)][1 inch (25 mm)]<Insert dimension> wide.
 9. Filter-Mounting Frame: <Insert frame size and style>.
 10. Some manufacturers can supply a filter-mounting frame on a limited number of grille dimensions. Verify with manufacturer before specifying.
 11. Mounting: [Countersunk screw][Concealed][Lay in].
 12. Damper Type: Adjustable opposed blade.

2.3 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate registers and grilles in accordance with ASHRAE 70.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where registers and grilles are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF REGISTERS AND GRILLES

- A. Install registers and grilles level and plumb.
- B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 36 13 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 36 13 00	23 36 00 00	Air Terminal Units
23 36 16 00	23 36 00 00	Air Terminal Units
23 36 16 00	23 36 13 00	Registers and Grilles
23 37 00 00	23 31 16 23	Fabric Air-Distribution Devices
23 37 13 00	23 36 13 00	Registers and Grilles
23 37 13 00	23 31 16 23	Fabric Air-Distribution Devices



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 37 13 13 - AIR DIFFUSERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ceiling diffusers - round face.
2. Ceiling diffusers - rectangular and square face.
3. Diffusers - perforated face.
4. Diffusers - louver face.
5. Diffusers - linear bar.
6. Diffusers - ceiling-integral plenum slot.
7. Diffusers - ceiling-linear continuous slot.
8. Diffusers - light troffer.
9. Diffusers - induction underfloor air distribution, round.
10. Diffuser plenums - linear underfloor air distribution.
11. Diffusers - drum louvers, high capacity.
12. Diffusers - modular-core grille, high capacity.
13. Diffusers - HEPA, laminar flow, filtered.
14. Diffusers - jet nozzle and punkah.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
2. Section 233713.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.
3. Section 233713.43 "Security Registers and Grilles" for security registers and security grilles.
4. Section 233716 "Fabric Air-Diffusion Devices" for continuous tubular diffusers.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - b. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified. Actual size of smallest diffuser indicated.

C. Samples for Initial Selection: For diffusers with factory-applied color finishes. Actual size of smallest diffuser indicated.

D. Samples for Verification: For diffusers, in manufacturer's standard sizes to verify color selected. Actual size of smallest diffuser indicated.



1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Ceiling suspension assembly members.
 2. Method of attaching hangers to building structure.
 3. Size and location of initial access modules for acoustical tile.
 4. Ceiling-mounted items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
 5. Duct access panels.
- B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS - ROUND FACE

- A. Ceiling Diffuser - Round Face :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - b. **[Carnes Company]**
 - c. **[Hart & Cooley, LLC]**
 - d. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - e. **[METALAIRE, Inc]**
 - f. **[Nailor Industries Inc]**
 - g. **[Price Industries Limited]**
 - h. **[Shoemaker Mfg. Co.]**
 - i. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - j. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - k. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - b. **[Carnes Company]**
 - c. **[Hart & Cooley, LLC]**
 - d. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - e. **[METALAIRE, Inc]**
 - f. **[Nailor Industries Inc]**
 - g. **[Price Industries Limited]**
 - h. **[Shoemaker Mfg. Co.]**
 - i. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - j. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - k. **<Insert manufacturer's name>**

3. Description: Round ceiling diffuser with duct collar and a series of conical curved blades to provide discharge parallel to ceiling surface.
4. Source Limitations: Obtain from single source from single manufacturer.
5. Material: **[Steel][Aluminum][Stainless steel]**.
6. Finish: **[Baked enamel, white][Baked enamel, color selected by Architect][Anodized aluminum]<Insert finish>**.
7. Face Style: **[Four][Three][Two]** cone.
8. Mounting: **[Ceiling][Duct]**.
9. Pattern: **[Fixed][Adjustable]**.
10. Dampers: **[Radial opposed blade][Butterfly][Combination damper and grid]**.
11. Accessories:
 - a. Equalizing grid.
 - b. Plaster ring.
 - c. Safety chain.
 - d. Wire guard.
 - e. Sectorizing baffles.
 - f. Manual remote balancing damper operator.
 - g. UL 555C fire-rated assembly, including fire damper and insulating blanket.

2.2 CEILING DIFFUSERS - RECTANGULAR AND SQUARE FACE

A. Ceiling Diffuser - Rectangular and Square :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Hart & Cooley, LLC]**
 - e. **[Kees, Inc]**
 - f. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - g. **[METALAIRE, Inc]**
 - h. **[Nailor Industries Inc]**
 - i. **[Price Industries Limited]**
 - j. **[Raymon Company]**
 - k. **[Shoemaker Mfg. Co.]**
 - l. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - m. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - n. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Hart & Cooley, LLC]**
 - e. **[Kees, Inc]**
 - f. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - g. **[METALAIRE, Inc]**

- h. [Nailor Industries Inc]
 - i. [Price Industries Limited]
 - j. [Raymon Company]
 - k. [Shoemaker Mfg. Co.]
 - l. [Titus; brand of Johnson Controls International plc, Global Products]
 - m. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - n. <Insert manufacturer's name>
3. Description: [Square][Rectangular] ceiling diffuser with round or rectangular duct collar and a series of curved louvers to provide discharge parallel to ceiling surface.
 4. Source Limitations: Obtain from single source from single manufacturer.
 5. Material: [Steel][Aluminum][Stainless steel].
 6. Finish: [Baked enamel, white][Baked enamel, color selected by Architect][Anodized aluminum]<Insert finish>.
 7. Face Size: [24 by 24 inches (600 by 600 mm)][20 by 20 inches (500 by 500 mm)][12 by 12 inches (300 by 300 mm)]<Insert dimensions>.
 8. Face Style: [Three cone][Four cone][Plaque].
 9. Mounting: [Surface][T-bar][Snap in][Spline][Mounting panel].
 10. Pattern: [Fixed][Two position][Adjustable].
 11. Dampers: [Radial opposed blade][Butterfly][Combination damper and grid].
 12. Accessories:
 - a. Equalizing grid.
 - b. Plaster ring.
 - c. Safety chain.
 - d. Wire guard.
 - e. Sectorizing baffles.
 - f. Manual remote balancing damper operator.
 - g. UL 555C fire-rated assembly, including fire damper and insulating blanket.

2.3 DIFFUSERS - PERFORATED FACE

A. Diffuser - Perforated Face :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [A-J Manufacturing Co., Inc]
 - b. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - c. [Carnes Company]
 - d. [Kees, Inc]
 - e. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 - f. [METALAIRES, Inc]
 - g. [Nailor Industries Inc]
 - h. [Price Industries Limited]
 - i. [Raymon Company]
 - j. [Shoemaker Mfg. Co.]
 - k. [Titus; brand of Johnson Controls International plc, Global Products]
 - l. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - m. [Warren Technology]
 - n. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Kees, Inc]**
 - e. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - f. **[METALAIRE, Inc]**
 - g. **[Nailor Industries Inc]**
 - h. **[Price Industries Limited]**
 - i. **[Raymon Company]**
 - j. **[Shoemaker Mfg. Co.]**
 - k. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - l. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - m. **[Warren Technology]**
 - n. **<Insert manufacturer's name>**
3. Description: Square ceiling diffuser with duct collar and perforated face plate.
4. Source Limitations: Obtain from single source from single manufacturer.
5. Material: Steel backpan and pattern controllers, with **[steel][aluminum]** face.
6. Finish: **[Baked enamel, white][Baked enamel, color selected by Architect][Anodized aluminum]<Insert finish>**.
7. Face Size: **[12 by 12 inches (300 by 300 mm)][24 by 12 inches (600 by 300 mm)][36 by 12 inches (900 by 300 mm)][48 by 12 inches (1200 by 300 mm)][16 by 16 inches (400 by 400 mm)][20 by 20 inches (500 by 500 mm)][24 by 24 inches (600 by 600 mm)][36 by 24 inches (900 by 600 mm)][48 by 24 inches (1200 by 600 mm)]<Insert dimensions>**.
8. Duct Inlet: **[Round][Square]**.
9. Face Style: **[Flush][Drop extended]**.
10. Mounting: **[Surface][T-bar][Snap in][Spline][Mounting panel]**.
11. Pattern Controller: **[Four louvered deflector patches][Fixed with curved blades at inlet][Adjustable with louvered pattern modules at inlet][None]**.
12. Dampers: **[Opposed blade][Radial opposed blade][Butterfly][Combination damper and grid]**.
13. Accessories:
 - a. Equalizing grid.
 - b. Plaster ring.
 - c. Safety chain.
 - d. Wire guard.
 - e. Sectorizing baffles.
 - f. Manual remote balancing damper operator.
 - g. UL 555C fire-rated assembly, including fire damper and insulating blanket.

2.4 DIFFUSERS - LOUVER FACE

A. Diffuser - Louver Face :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A-J Manufacturing Co., Inc]**



- b. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - c. [Carnes Company]
 - d. [Hart & Cooley, LLC]
 - e. [Kees, Inc]
 - f. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 - g. [METALAIRE, Inc]
 - h. [Nailor Industries Inc]
 - i. [Price Industries Limited]
 - j. [Raymon Company]
 - k. [Shoemaker Mfg. Co.]
 - l. [Titus; brand of Johnson Controls International plc, Global Products]
 - m. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - n. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [A-J Manufacturing Co., Inc]
 - b. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - c. [Carnes Company]
 - d. [Hart & Cooley, LLC]
 - e. [Kees, Inc]
 - f. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 - g. [METALAIRE, Inc]
 - h. [Nailor Industries Inc]
 - i. [Price Industries Limited]
 - j. [Raymon Company]
 - k. [Shoemaker Mfg. Co.]
 - l. [Titus; brand of Johnson Controls International plc, Global Products]
 - m. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - n. <Insert manufacturer's name>
3. Description: Square diffuser with outer border, duct collar, and curved face louvers to direct air discharge in one, two, three, or four directions, parallel to ceiling surface.
4. Source Limitations: Obtain from single source from single manufacturer.
5. Material: [Steel][Aluminum][Stainless Steel].
6. Finish: [Baked enamel, white][Baked enamel, color selected by Architect][Anodized aluminum]<Insert finish>.
7. Face Size: <Insert inches (mm) by inches (mm)>.
8. Mounting: [Surface][Surface with beveled frame][T-bar][Snap in][Spline][Mounting panel].
9. Pattern: [One-way][Two-way][Two-way corner][Three-way][Four-way][Adjustable]<Insert pattern> core style[as indicated on the Drawings].
10. Dampers: [Radial opposed blade][Butterfly][Combination damper and grid].
11. Accessories:
 - a. Square to round neck adaptor.
 - b. Adjustable pattern vanes.
 - c. Throw reducing vanes.
 - d. Equalizing grid.
 - e. Plaster ring.
 - f. Safety chain.
 - g. Wire guard.
 - h. Sectorizing baffles.
 - i. Manual remote balancing damper operator.

- j. UL 555C fire-rated assembly including fire damper and insulating blanket.

2.5 DIFFUSERS - LINEAR BAR

A. Diffuser - Linear Bar :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - b. **[Carnes Company]**
 - c. **[Dayus Register & Grille Inc.]**
 - d. **[Hart & Cooley, LLC]**
 - e. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - f. **[METALAIRE, Inc]**
 - g. **[Nailor Industries Inc]**
 - h. **[Price Industries Limited]**
 - i. **[Raymon Company]**
 - j. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - k. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - b. **[Carnes Company]**
 - c. **[Dayus Register & Grille Inc.]**
 - d. **[Hart & Cooley, LLC]**
 - e. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - f. **[METALAIRE, Inc]**
 - g. **[Nailor Industries Inc]**
 - h. **[Price Industries Limited]**
 - i. **[Raymon Company]**
 - j. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - k. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - l. **<Insert manufacturer's name>**
3. Description: Frame with multiple fixed or adjustable vanes or blades to deflect supply air direction. Frame width and length are as indicated **[on Drawings][in Specifications]**.
4. Source Limitations: Obtain from single source from single manufacturer.
5. Material: **[Steel][Aluminum][Stainless steel]**.
6. Finish: **[Baked enamel, white][Baked enamel, color selected by Architect]<Insert finish>**.
7. Narrow Core Spacing Arrangement: **1/8-inch- (3-mm-)** thick blades spaced **1/4 inch (6 mm)** apart; **[zero][15]**-degree deflection.
8. Wide Core Spacing Arrangement:
 - a. **1/8-inch- (3-mm-)** thick blades spaced **1/2 inch (13 mm)** apart; **[zero][15]**-degree deflection.
 - b. **3/16-inch- (5-mm-)** thick blades spaced **1/2 inch (13 mm)** apart; **[zero][15][30]**-degree deflection.

9. Pencil-Proof Core Spacing Arrangement: **3/16-inch- (5-mm-)** thick blades spaced **7/16 inch (11 mm)** apart; **[zero][15][30]**-degree deflection.
10. Deflection Vanes:
 - a. One-Way Deflection Vanes: Extruded construction; **[fixed][adjustable]** louvers with removable core.
 - b. Two-Way Deflection Vanes: Extruded construction; **[fixed][adjustable]** louvers with removable core.
11. Frame: **[1-1/4 inches (32 mm)][1 inch (25 mm)][3/4 inch (19 mm)][1/2 inch (13 mm)][3/16 inch (5 mm)]** wide.
12. Mounting Frame: **[Filter]<Insert frame size and style>**.
13. Mounting: **[Countersunk screw][Concealed bracket][Spring clip]**.
14. Damper Type: **[Adjustable opposed-blade assembly][Hinged single blade]**.
15. Accessories: **[Plaster frame][Directional vanes][Alignment pins][Core clips][Blank-off strips]**.

2.6 DIFFUSERS - CEILING-INTEGRAL PLENUM SLOT

A. Diffuser - Ceiling-Integral Plenum Slot :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - b. **[Carnes Company]**
 - c. **[Hart & Cooley, LLC]**
 - d. **[Kees, Inc]**
 - e. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - f. **[METALAIRE, Inc]**
 - g. **[Nailor Industries Inc]**
 - h. **[Price Industries Limited]**
 - i. **[Raymon Company]**
 - j. **[Shoemaker Mfg. Co.]**
 - k. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - l. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - b. **[Carnes Company]**
 - c. **[Hart & Cooley, LLC]**
 - d. **[Kees, Inc]**
 - e. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - f. **[METALAIRE, Inc]**
 - g. **[Nailor Industries Inc]**
 - h. **[Price Industries Limited]**
 - i. **[Raymon Company]**
 - j. **[Shoemaker Mfg. Co.]**
 - k. **[Titus; brand of Johnson Controls International plc, Global Products]**

- l. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
- m. **<Insert manufacturer's name>**
3. Description: Diffuser assembly with integral pattern controller, one or more linear discharge slots, and an integral plenum and duct collar. Assembly is to be installed in modular T-bar ceilings.
4. Source Limitations: Obtain from single source from single manufacturer.
5. Material:
 - a. Face: **[Steel][Aluminum]**.
 - b. Pattern Controller and Tees: Aluminum.
 - c. Plenum: Steel[, **internally insulated**][, **uninsulated**].
 - d. Plenum Insulation: Comply with UL 181.
6. Finish:
 - a. Face and Plenum: **[Baked enamel]<Insert finish>**.
 - b. Pattern Controller: **[Baked enamel, black]<Insert finish>**.
 - c. Tees: **[Baked enamel, white][Baked enamel, color selected by Architect]<Insert finish>**.
7. Slot Width: **[1/2 inch (13 mm)][3/4 inch (19 mm)][1 inch (25 mm)][1-1/2 inches (38 mm)]**.
8. Number of Slots: **[One][Two][Three][Four]<Insert number>**.
9. Length: **[24 inches (600 mm)][30 inches (750 mm)][36 inches (900 mm)][48 inches (1200 mm)][60 inches (1500 mm)]**.
10. Accessories: **[Plaster frame][T-bar slot][Center notch][T-bar on inlet side][T-bar on both sides][T-bar clip on one side][T-bar clips on both sides]**.
11. Fire-Rated Construction: Integral fire damper and fire-rated assembly listing in the Underwriters Laboratory Fire Resistance Directory, tested in accordance with UL 263 and complying with NFPA 90A requirements.

2.7 DIFFUSERS - CEILING-LINEAR CONTINUOUS SLOT

A. Diffuser - Ceiling-Linear Continuous Slot :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - b. **[Carnes Company]**
 - c. **[Dayus Register & Grille Inc.]**
 - d. **[Hart & Cooley, LLC]**
 - e. **[Kees, Inc]**
 - f. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - g. **[METALAIRE, Inc]**
 - h. **[Nailor Industries Inc]**
 - i. **[Price Industries Limited]**
 - j. **[Raymon Company]**
 - k. **[Shoemaker Mfg. Co.]**
 - l. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - m. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - n. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - b. **[Carnes Company]**
 - c. **[Dayus Register & Grille Inc.]**
 - d. **[Hart & Cooley, LLC]**
 - e. **[Kees, Inc]**
 - f. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - g. **[METALAIRE, Inc]**
 - h. **[Nailor Industries Inc]**
 - i. **[Price Industries Limited]**
 - j. **[Raymon Company]**
 - k. **[Shoemaker Mfg. Co.]**
 - l. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - m. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - n. **<Insert manufacturer's name>**
3. Description: Linear diffuser assembly with continuous slots; adjustable vane in each slot to direct airflow in required direction.
 4. Source Limitations: Obtain from single source from single manufacturer.
 5. Slot Width: **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)][2-1/2 inches (63 mm)][3 inches (76 mm)]**.
 6. Section Length: **[12 ft. (3.7 m)]<Insert dimension>**.
 7. Straight and curved sections as required to accommodate layout.
 8. Mitered tees and corners.
 9. Pattern control vanes.
 10. Material: Aluminum, extruded, heavy wall.
 11. Finishes:
 - a. Exterior: Standard white.
 - b. Interior: Standard black.
 12. Throw: **[Horizontal][Vertical]**.
 13. Mounting: **[Ceiling][Sidewall]**.
 14. Plenum: **[Noninsulated][Insulated]**.
 15. Other Features:
 - a. Blank-offs.

2.8 DIFFUSERS - LIGHT TROFFER

A. Diffuser - Light Troffer :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[METALAIRE, Inc]**
 - b. **[Price Industries Limited]**
 - c. **[Raymon Company]**
 - d. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[METALAIRE, Inc]**
 - b. **[Price Industries Limited]**
 - c. **[Raymon Company]**
 - d. **<Insert manufacturer's name>**
3. Description: Combined plenum, inlet, and attachment device for an air-handling light fixture. Unit is to be custom designed to fit light fixtures provided under Section 265000 "Lighting."
4. Source Limitations: Obtain from single source from single manufacturer.
5. Material: Steel **[with external insulation]**.
6. Finish: **[None][Black enamel on visible surfaces]<Insert finish>**.
7. Slot Width: **[1/2 inch (13 mm)][3/4 inch (19 mm)][1 inch (25 mm)][1-1/2 inches (38 mm)]**.
8. Slot Location: **[One side][Two sides]**.
9. Length: **[24 inches (600 mm)][36 inches (900 mm)][48 inches (1200 mm)]**.
10. Pattern: **[Fixed][Adjustable]**.
11. Inlet: **[Top][Side]**.
12. Inlet Size: **[5 inches (125 mm)][6 inches (150 mm)][8 inches (200 mm)]**.

2.9 DIFFUSERS - INDUCTION UNDERFLOOR AIR-DISTRIBUTION, ROUND

A. Diffuser - Induction Underfloor Air Distribution, Round :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Nailor Industries Inc]**
 - b. **[Price Industries Limited]**
 - c. **[Tate Access Floors, Inc]**
 - d. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Nailor Industries Inc]**
 - b. **[Price Industries Limited]**
 - c. **[Tate Access Floors, Inc]**
 - d. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - e. **<Insert manufacturer's name>**
3. Description: Round face, with openings arranged in a radial pattern to promote a high degree of room air entrainment. Unit is suitable for floor, wall, or ceiling mounting.
4. Source Limitations: Obtain from single source from single manufacturer.
5. Airflow Principle: Swirl-pattern induction.
6. Material: **[High-impact polycarbonate plastic, resistant to cart and foot traffic; tested in accordance with NFPA 90B and UL 94.][Cast aluminum, resistant to cart and foot traffic; tested and approved in accordance with NFPA 90B and UL 2043.]**
7. Air-Flow Adjustment: **[Manual][Automatic, for connection to building automatic control system][Automatic, for control by local space thermostat]**.



8. Color: **[Gray][Black]**.
9. Components:
 - a. Diffuser core.
 - b. Flow regulator.
 - c. Dirt and liquid catch pan.
 - d. Spacer flange.
 - e. Gasketed, underfloor compression ring.

2.10 DIFFUSER PLENUMS - LINEAR UNDERFLOOR AIR-DISTRIBUTION

A. Diffuser Plenum - Linear Underfloor Air Distribution :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - b. **[Carnes Company]**
 - c. **[Hart & Cooley, LLC]**
 - d. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - e. **[METALAIRE, Inc]**
 - f. **[Nailor Industries Inc]**
 - g. **[Price Industries Limited]**
 - h. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - b. **[Carnes Company]**
 - c. **[Hart & Cooley, LLC]**
 - d. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - e. **[METALAIRE, Inc]**
 - f. **[Nailor Industries Inc]**
 - g. **[Price Industries Limited]**
 - h. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - i. **<Insert manufacturer's name>**
3. Description: Frame with multiple fixed vanes or blades to deflect supply air direction and provide substantial surface for foot traffic.
4. Source Limitations: Obtain from single source from single manufacturer.
5. Material: **[Steel][Aluminum]**.
6. Finish: White baked acrylic.
7. Deflection: **[Zero][15]** degrees.
8. Components:
 - a. Aluminum diffuser core.
 - b. Diffuser frame.
 - c. Plenum, **0.034-inch (0.85-mm)** steel.

2.11 DIFFUSERS - DRUM LOUVERS, HIGH CAPACITY

A. Diffuser - Drum Louver, High Capacity :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Hart & Cooley, LLC]**
 - e. **[Kees, Inc]**
 - f. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - g. **[METALAIRE, Inc]**
 - h. **[Nailor Industries Inc]**
 - i. **[Price Industries Limited]**
 - j. **[Raymon Company]**
 - k. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - l. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Hart & Cooley, LLC]**
 - e. **[Kees, Inc]**
 - f. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - g. **[METALAIRE, Inc]**
 - h. **[Nailor Industries Inc]**
 - i. **[Price Industries Limited]**
 - j. **[Raymon Company]**
 - k. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - l. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - m. **<Insert manufacturer's name>**
3. Description: High-capacity supply air outlet with adjustable blades for horizontal jet or diffused air patterns and rotatable cylindrical drum for vertical directional control.
4. Source Limitations: Obtain from single source from single manufacturer.
5. Airflow Principle: Extended distance for high airflow rates.
6. Material: **[Aluminum][Stainless steel]**, heavy gauge extruded.
7. Finish: White baked acrylic.
8. Border: **1-1/4-inch (32-mm)** width with countersunk screw holes.
9. Gasket between drum and border.
10. Body: Drum shaped; adjustable vertically.
11. Blades: Individually adjustable horizontally.
12. Mounting: Surface to **[duct][wall]**.
13. Inlet Width: **[6 inches (150 mm)][10 inches (250 mm)][12 inches (300 mm)][15 inches (380 mm)]<Insert dimension>**.
14. Inlet Length: **[12 inches (300 mm)][24 inches (600 mm)][36 inches (900 mm)][60 inches (1500 mm)]<Insert dimension>**.

15. Accessories:

- a. Opposed-blade steel damper.
- b. Duct-mounting collars with countersunk screw holes.

2.12 DIFFUSERS - MODULAR-CORE GRILLE, HIGH CAPACITY**A. Diffuser - Modular-Core Grille, High Capacity :**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Hart & Cooley, LLC]**
 - e. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - f. **[METALAIRE, Inc]**
 - g. **[Nailor Industries Inc]**
 - h. **[Price Industries Limited]**
 - i. **[Shoemaker Mfg. Co.]**
 - j. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - k. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Hart & Cooley, LLC]**
 - e. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - f. **[METALAIRE, Inc]**
 - g. **[Nailor Industries Inc]**
 - h. **[Price Industries Limited]**
 - i. **[Shoemaker Mfg. Co.]**
 - j. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - k. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - l. **<Insert manufacturer's name>**
3. Description: **[Square][Rectangular]** ceiling diffuser with round or rectangular duct collar and multiple modular cores that can each be adjusted to deflect airflow in required direction. Each core is to have a series of curved louvers to provide discharge parallel to ceiling surface.
4. Source Limitations: Obtain from single source from single manufacturer.
5. Throw: As scheduled on the Drawings.
6. Material: Steel.
7. Grille Core Modules per Unit: **[One][Two][Three][Four]**.
8. Finish: White baked acrylic.
9. Border: **1-1/2-inch (38-mm)** width.
10. Modules: Removable; rotatable.

11. Mounting: Surface.
12. Accessory: Opposed-blade steel damper.

2.13 DIFFUSERS - HEPA, LAMINAR-FLOW FILTERED

A. Diffuser - HEPA, Laminar Flow, Filtered :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Kees, Inc]**
 - e. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - f. **[METALAIRE, Inc]**
 - g. **[Nailor Industries Inc]**
 - h. **[Shoemaker Mfg. Co.]**
 - i. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - j. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Kees, Inc]**
 - e. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - f. **[METALAIRE, Inc]**
 - g. **[Nailor Industries Inc]**
 - h. **[Shoemaker Mfg. Co.]**
 - i. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - j. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - k. **<Insert manufacturer's name>**
3. Description: Factory-fabricated, individually ducted, HEPA filter-holding ceiling modules.
4. Source Limitations: Obtain from single source from single manufacturer.
5. Standards:
 - a. Comply with IEST-RP-CC001.7.
 - b. Comply with IEST-RP-CC034.4.
 - c. Comply with UL 586.
6. Media: Fibrous glass, constructed of continuous sheets with closely spaced pleats with separators.
 - a. Media-to-Frame Side Bond: Urethane or polyurethane sealant.
 - b. Frame-to-Grid Bond: **<Insert type of gasket>[gasket]; knife edge for gel-filled channel**.
 - c. Application: **[Class 100,000 (ISO 8)][Class 10,000 (ISO 7)][Class 1,000**

(ISO 6)][Class 100 (ISO 5)][Class 10 (ISO 4)]<Insert class> clean room.

7. Casing:
 - a. Configuration: **[Ducted][Plenum]** inlet.
 - b. Module Material: **[Minimum 16-gauge (0.508-mm) extruded aluminum]<Insert gauge and material>** with **[mill]<Insert type>** finish.
 - c. Face Size: **<Insert inches (mm) by inches (mm)>**.
 - d. Suspension: **[Ceiling grid][Independent]**.
8. Accessories:
 - a. **[Fixed][Adjustable]** diffusion damper.
 - b. Diffusion-damper adjustment port.
 - c. Filter test port.

2.14 DIFFUSERS - JET NOZZLE AND PUNKAH

A. Diffuser - Jet Nozzle and Punkah :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following)][provide products by one of the following)][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Kees, Inc]**
 - b. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - c. **[METALAIRE, Inc]**
 - d. **[Nailor Industries Inc]**
 - e. **[Price Industries Limited]**
 - f. **[Shoemaker Mfg. Co.]**
 - g. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - h. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Kees, Inc]**
 - b. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - c. **[METALAIRE, Inc]**
 - d. **[Nailor Industries Inc]**
 - e. **[Price Industries Limited]**
 - f. **[Shoemaker Mfg. Co.]**
 - g. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - h. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - i. **<Insert manufacturer's name>**
3. Description: High-velocity, high-capacity round nozzle with provision to adjust air-discharge direction in both horizontal and vertical plane.
4. Source Limitations: Obtain from single source from single manufacturer.
5. Style: **[Jet nozzle][Punkah]**.
6. Throw: As scheduled.

7. Material: **[Steel][Aluminum]**.
8. Nozzles per Unit: **[One][Two][Three][Four]**.
9. Nozzle Size: **[Insert size here]**.
10. Finish: White baked acrylic.
11. Border: **1-1/2-inch (38-mm)** width with countersunk screw holes.
12. Blades:
 - a. Concentric rings adjustable both horizontally and vertically.
 - b. Set in modules.
13. Nozzle:
 - a. Round inner nozzle and round outer frame.
 - b. Manually adjustable discharge direction without use of tools.
14. Modules: Removable; rotatable.
15. Mounting: Surface.
16. Accessory: Steel volume control damper.

2.15 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers in accordance with ASHRAE 70.

PART 3 - EXECUTION

3.1 INSTALLATION OF AIR DIFFUSERS

- A. Install diffusers level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

- A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13 13



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 37 13 13	23 33 00 00	Air Duct Accessories
23 37 13 13	23 36 13 00	Registers and Grilles
23 37 13 13	23 31 16 23	Fabric Air-Distribution Devices



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 37 13 43 - SECURITY REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Security registers.
2. Security grilles.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
2. Section 233713.13 "Air Diffusers" for various types of air diffusers.
3. Section 233713.23 "Registers and Grilles" for registers and grilles.
4. Section 233716 "Fabric Air-Distribution Devices" for continuous tubular diffusers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Data Sheet: Indicate materials of construction, finish, mounting details, and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For security registers and grilles with factory-applied color finishes.

C. Samples for Verification: For security registers and grilles, in manufacturer's standard sizes to verify color selected.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Source quality control reports.

PART 2 - PRODUCTS

2.1 SECURITY REGISTERS

A. Security Register :

1. Manufacturers: Subject to compliance with requirements, [provide products by the

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [A-J Manufacturing Co., Inc]
 - b. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - c. [Carnes Company]
 - d. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 - e. [Nailor Industries Inc]
 - f. [Price Industries Limited]
 - g. [Titus; brand of Johnson Controls International plc, Global Products]
 - h. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [A-J Manufacturing Co., Inc]
 - b. [Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]
 - c. [Carnes Company]
 - d. [Krueger-HVAC; brand of Johnson Controls International plc, Global Products]
 - e. [Nailor Industries Inc]
 - f. [Price Industries Limited]
 - g. [Titus; brand of Johnson Controls International plc, Global Products]
 - h. [Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]
 - i. <Insert manufacturer's name>
3. Security Level: [Maximum][Medium][Minimum][and suicide deterrent]. Comply with requirements of National Institute of Corrections.
4. Application: [Ducted supply][Ducted return][Air transfer][Barrier].
5. Material: [Steel][Stainless Steel][Aluminum].
6. Material Thickness: [0.19 inch (4.8 mm)]<Insert dimension>.
7. Finish: [Unfinished][Baked enamel, white][Baked enamel, color selected by Architect]<Insert finish>.
8. Face Arrangement:
- a. Shape: [Square][Rectangular][Round].
 - b. Design: [Fixed bar][Perforated][Lattice].
 - c. Frame: [Yes][No].
 - d. Deflection: [Zero][38]<Insert angle>degrees.
 - e. Core: [None][Louvered].
 - f. 3/16-inch- (5-mm-) thick, front lattice plate with 2-by-2-inch- (50-by-50-mm-) square holes and 1-inch (25-mm) frets, 0.135-inch (3.43-mm) wire mesh, and 1/4-inch- (6-mm-) thick backer plate.
 - g. 3/16-inch- (5-mm-) thick, perforated faceplate with 5/16-inch- (8-mm-) diameter holes spaced 7/16 inch (11 mm) o.c., staggered at 60 degrees.
 - h. 1-1/2-inch (38-mm) bars and mandrel tubes and rods with [zero][15]-degree deflection in 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) angle border.
 - i. 1-3/8-inch (35-mm) bars and double mandrel tubes with [zero][15]-degree deflection in 1-3/4-inch (45-mm) angle border.
9. Damper Operation: [None][Face operated][Rear operated].
10. Damper Type: [Multi-shutter][Adjustable opposed blade][NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C)].

11. Wall Sleeve: **[3/16 inch (5 mm) welded to face][1/8 inch (3 mm) welded to face]<Insert length>**sleeve length;**[mechanically fastened to border]**.
12. Mounting: **[1-by-1-by-3/16-inch (25-by-25-by-5-mm) retaining angle frame][1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) retaining angle frame][1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) cast-in-place frame and tamperproof machine screws]**.

2.2 SECURITY GRILLES

A. Security Grille :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - e. **[Nailor Industries Inc]**
 - f. **[Price Industries Limited]**
 - g. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - h. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A-J Manufacturing Co., Inc]**
 - b. **[Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.]**
 - c. **[Carnes Company]**
 - d. **[Krueger-HVAC; brand of Johnson Controls International plc, Global Products]**
 - e. **[Nailor Industries Inc]**
 - f. **[Price Industries Limited]**
 - g. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - h. **[Tuttle & Bailey; brand of Johnson Controls International plc, Global Products]**
 - i. **<Insert manufacturer's name>**
3. Security Level: **[Maximum][Medium][Minimum][and suicide deterrent]**. Comply with requirements of National Institute of Corrections.
4. Application: **[Ducted supply][Ducted return][Air transfer][Barrier]**.
5. Material: **[Steel][Stainless Steel][Aluminum]**.
6. Material Thickness: **[0.19 inch (4.8 mm)]<Insert dimension>**.
7. Finish: **[Unfinished][Baked enamel, white][Baked enamel, color selected by Architect]<Insert finish>**.
8. Face Arrangement:
 - a. Shape: **[Square][Rectangular][Round]**.
 - b. Design: **[Fixed bar][Perforated][Lattice]**.
 - c. Frame: **[Yes][No]**.
 - d. Deflection: **[Zero][38]<Insert angle>**degrees.
 - e. Core: **[None][Louvered]**.
 - f. **3/16-inch- (5-mm-) thick, front lattice plate with 2-by-2-inch- (50-by-50-mm-) square holes and 1-inch (25-mm) frets, 0.135-inch (3.43-mm) wire mesh, and 1/4-inch- (6-mm-) thick**

- g. backer plate.
3/16-inch- (5-mm-) thick perforated faceplate with 5/16-inch- (8-mm-) diameter holes spaced 7/16 inch (11 mm) o.c., staggered at 60 degrees.
 - h. 1-1/2-inch (38-mm) bars and mandrel tubes and rods with [zero][15]-degree deflection in 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) angle border.
 - i. 1-3/8-inch (35-mm) bars and double mandrel tubes with [zero][15]-degree deflection in 1-3/4-inch (45-mm) angle border.
9. Wall Sleeve: [3/16 inch (5 mm) welded to face][1/8 inch (3 mm) welded to face]<Insert sleeve length> sleeve length; [mechanically fastened to border].
10. Mounting: [1-by-1-by-3/16-inch (25-by-25-by-5-mm) retaining angle frame][1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) retaining angle frame][1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) cast-in-place frame and tamperproof machine screws].

2.3 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate registers and grilles in accordance with ASHRAE 70.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where security registers and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SECURITY REGISTERS AND GRILLES

- A. Install security registers and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. Where architectural features, lighting fixtures, sprinklers, or other items conflict with installation, coordinate with other trades and notify Architect for a determination of final location.
- C. Install security registers and grilles with airtight connections to ducts.
- D. Provide access to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust security registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13 43



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 37 13 43	23 33 00 00	Air Duct Accessories
23 37 13 43	23 36 13 00	Registers and Grilles
23 37 13 43	23 31 16 23	Fabric Air-Distribution Devices



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 37 23 00 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Louvered-penthouse ventilators.
2. Hooded ventilators.
3. Goosenecks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For gravity ventilators.

1. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
2. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

D. Samples: For each exposed product and for each color and texture specified.

E. Samples for Initial Selection: For units with factory-applied color finishes.

F. Samples for Verification: For each type of louvered-penthouse ventilator indicated, in manufacturer's standard size.

G. Delegated Design Submittal: For shop-fabricated ventilators indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of shop-fabricated ventilators.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof-framing plans and other details, drawn to scale, and coordinated with each other, based on input from installers of the items involved:

B. Seismic Qualification Data: Certificates for ventilators, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and

3. describe mounting and anchorage provisions.
Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.5 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design ventilators.
- B. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.
1. Wind Loads, Indicated on Drawings: Determine loads based on pressures as indicated on Drawings.
 2. Wind Loads, Basis: Determine loads based on a uniform pressure of [20 (960)][30 (1440)]<Insert design wind pressure> lbf/sq. ft. (Pa), acting inward or outward.
 3. Wind Loads, Indicated Below: Determine loads based on pressures indicated below:
 - a. Corner Zone: Within <Insert distance> of building corners, uniform pressure of <Insert design wind pressure>, acting inward, and <Insert design wind pressure>, acting outward.
 - b. Other Than Corner Zone: Uniform pressure of <Insert design wind pressure>, acting inward, and <Insert design wind pressure>, acting outward.
 4. See [Section 230548 "Vibration and Seismic Controls for HVAC"] [Section 230548.13 "Vibration Controls for HVAC"] for wind-load requirements.
 5. Snow Load: Unit to withstand a minimum of [20- (960-)]<Insert design snow load pressure> lbf/sq. ft. (Pa) snow load.
- C. Seismic Performance: Ventilators, including attachments to other construction, shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7]<Insert requirement>. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. ASHRAE 62.1 Compliance: Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."
- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.
1. Temperature Change (Range):
 - a. Ambient: **[120 (67)]<Insert temperature> deg F (deg C)**.
 - b. Material Surfaces: **[180 (100)]<Insert temperature> deg F (deg C)**.
- G. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.
- H. Capacities and Characteristics:
1. Drawing Tag No.: **<Insert number>**.
 2. Type: **[Louvered penthouse][Hooded penthouse][Gooseneck]**.
 3. Height: **<Insert number> inches (mm)**.
 4. Width: **<Insert number> inches (mm)**.
 5. Depth: **<Insert number> inches (mm)**.
 6. Air Flow: **<Insert number> cfm (L/s)**.
 7. Maximum Air Pressure Drop: Not more than **[0.10- (25-)]<Insert pressure> inch wg (Pa)** static pressure drop.
 8. Maximum Free Area Velocity: **[600 (3.0)][700 (3.6)][800 (4.1)]<Insert velocity> fpm (m/s)**.
 9. Function: **[Intake][Relief]**.

2.2 FABRICATION

- A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.
- B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
- C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
- D. Fabricate supports, anchorages, and accessories required for complete assembly.
- E. Perform shop welding by AWS-certified procedures and personnel.

2.3 LOUVERED-PENTHOUSE VENTILATORS

- A. Description: Multitier rectangular louvered penthouse for [intake][relief] air.
- B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [Acme Engineering & Manufacturing Corp.]
 2. [Aire Technologies, Inc.; DMI Companies]
 3. [Arrow United Industries; Mestek, Inc.]
 4. [Carnes Company]
 5. [Greenheck Fan Corporation]
 6. [JencoFan]
 7. [Loren Cook Company]
 8. [PennBarry; division of Air System Components]
 9. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 10. [Safe Air - Dowco]
 11. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Acme Engineering & Manufacturing Corp.]
 2. [Aire Technologies, Inc.; DMI Companies]
 3. [Arrow United Industries; Mestek, Inc.]
 4. [Carnes Company]
 5. [Greenheck Fan Corporation]
 6. [JencoFan]
 7. [Loren Cook Company]
 8. [PennBarry; division of Air System Components]
 9. [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 10. [Safe Air - Dowco]
 11. <Insert manufacturer's name>
- D. Source Limitations: Obtain louvered-penthouse ventilators from single manufacturer.
- E. Construction:
1. Material: All-welded assembly with [4-inch (100-mm)][6-inch (150-mm)]-deep louvers, mitered corners, and [aluminum][galvanized-steel] sheet roof.
 2. Frame and Blade Material, Extruded Aluminum: Thickness required to comply with structural performance requirements, but not less than [0.080 (2.0)]<Insert value> inch (mm) for frames and [0.080 (2.0)][0.060 (1.5)]<Insert value> inch (mm) for blades [with condensate deflectors].
 3. Frame and Blade Material, Galvanized-Steel Sheet: Thickness required to comply with structural performance requirements, but not less than [0.052 (1.3)]<Insert value> inch (mm) for frames and [0.040 (1.0)][0.052 (1.3)][0.064 (1.6)]<Insert value> inch (mm) for blades [with condensate deflectors].
 4. Insulation: [None][Mineral-fiber insulation and vapor barrier].
 5. Wind-Driven Rain Performance: Not less than [99][95][80]<Insert number> percent effectiveness when subjected to a rainfall rate of [3 inches (75 mm) per hour and a wind speed of 29 (13 m/s)]<Insert value> mph (m/s) at a free-area intake velocity of [300 (1.5)][400 (2.0)][500 (2.5)]<Insert velocity> fpm (m/s).
 6. Exterior Corners: Prefabricated corner units with [mitered and welded blades][mitered blades with concealed close-fitting splices] and with [fully recessed][semirecessed] mullions at

- corners.
7. Bird Screening: **[Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh wire][Aluminum, 1/2-inch- (12.7-mm-) square mesh or flattened, expanded aluminum, 3/4-inch- (19-mm-) diamond mesh wire]<Insert type>**.
 8. Insect Screening: **[Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh wire]<Insert type>**.
 9. Galvanized-Steel Sheet Finish:
 - a. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A780/A780M. Apply a conversion coating suited to the organic coating to be applied over it.
 - b. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
 - c. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of **1 mil (0.025 mm)** for topcoat and an overall minimum dry film thickness of **2 mils (0.05 mm)**.
 - 1) Color and Gloss: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]**.

F. Dampers:

1. Location: **[Penthouse neck][Inside louver face][Curb damper tray]**.
2. Control: **[Manual][Motorized][Gravity backdraft]**.
3. Tray: Provide damper tray or shelf with opening **[3 (76)]<Insert dimension> inches (mm) [less than interior curb dimensions indicated][of size indicated]**.

G. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; **1-1/2-inch- (40-mm-)** thick, rigid fiberglass insulation adhered to inside walls; and **1-1/2-inch (40-mm)** wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: **[Self-flashing without a cant strip, with][Built-in cant and][Built-in raised cant and]** mounting flange.
2. Overall Height: **[12 inches (300 mm)][36 inches (915 mm)]**.

2.4 HOODED VENTILATORS

A. Description: Hooded **[rectangular][round]** penthouse for **[intake][relief]** air.

B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Acme Engineering & Manufacturing Corp.]**
2. **[Carnes Company]**
3. **[Greenheck Fan Corporation]**
4. **[JencoFan]**
5. **[Loren Cook Company]**
6. **[PennBarry; division of Air System Components]**
7. **[Safe Air - Dowco]**
8. **[Twin City Fan & Blower]**
9. **<Insert manufacturer's name>**

C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's**

name; product name or designation> or comparable product by one of the following:

1. **[Acme Engineering & Manufacturing Corp.]**
2. **[Carnes Company]**
3. **[Greenheck Fan Corporation]**
4. **[JencoFan]**
5. **[Loren Cook Company]**
6. **[PennBarry; division of Air System Components]**
7. **[Safe Air - Dowco]**
8. **[Twin City Fan & Blower]**
9. **<Insert manufacturer's name>**

D. Source Limitations: Obtain hooded ventilators from single manufacturer.

E. Construction:

1. Material, Galvanized Steel: Thickness required to comply with structural performance requirements, but not less than **0.064-inch- (1.62 mm-)** thick base and **0.040-inch- (1.0-mm-)** thick hood; suitably reinforced.
2. Material, Aluminum: Thickness required to comply with structural performance requirements, but not less than **0.063-inch- (1.6-mm-)** thick base and **0.050-inch- (1.27-mm-)** thick hood; suitably reinforced.
3. Insulation: **[None][Mineral-fiber insulation and vapor barrier]**.
4. Bird Screening: **[Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh wire][Aluminum, 1/2-inch- (12.7-mm-) square mesh or flattened, expanded aluminum, 3/4-inch (19-mm) diamond mesh wire]<Insert type>**.
5. Insect Screening: **[Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh wire]<Insert type>**.

F. Galvanized-Steel Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A780/A780M. Apply a conversion coating suited to the organic coating to be applied over it.
2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of **1 mil (0.025 mm)** for topcoat and an overall minimum dry film thickness of **2 mils (0.05 mm)**.
 - a. Color and Gloss: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]**.

G. Dampers:

1. Location: **[Hood neck][Curb damper tray]**.
2. Control: **[Manual][Motorized][Gravity backdraft]**.
3. Tray: Provide damper tray or shelf with opening **[3 (76)]<Insert dimension> inches (mm) [less than interior curb dimensions indicated][of size indicated]**.

H. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; **1-1/2-inch- (40-mm-)** thick, rigid fiberglass insulation adhered to inside walls; and **1-1/2-inch (40-mm)** wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: **[Self-flashing without a cant strip, with][Built-in cant and][Built-in raised cant and]** mounting flange.

2. Overall Height: [12 inches (300 mm)][36 inches (900 mm)].

2.5 GOOSENECKS

- A. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 6-5; with a minimum of **0.052-inch- (1.3-mm-)** thick, galvanized-steel sheet.
- B. Bird Screening: **[Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh, 0.041-inch (1.04-mm) wire][Aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire][Flattened, expanded aluminum, 3/4 by 0.050 inch (19 by 1.27 mm) thick]<Insert type>.**
- C. Insect Screening: **[Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh, 0.012-inch (0.30-mm)]<Insert type>.**
- D. Galvanized-Steel Sheet Finish:
 1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A780/A780M. Apply a conversion coating suited to the organic coating to be applied over it.
 2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
 3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of **1 mil (0.025 mm)** for topcoat and an overall minimum dry film thickness of **2 mils (0.05 mm)**.
 - a. Color and Gloss: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range].**
- E. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; **1-1/2-inch- (40-mm-)** thick, rigid fiberglass insulation adhered to inside walls; and **1-1/2-inch (40-mm)** wood nailer. Size as required to fit roof opening and ventilator base.
 1. Configuration: **[Self-flashing without a cant strip, with][Built-in cant and][Built-in raised cant and]** mounting flange.
 2. Overall Height: [12 inches (300 mm)][36 inches (900 mm)].

2.6 SOURCE QUALITY CONTROL

- A. AMCA Certification for Hooded Ventilators: Test, rate, and label gravity ventilators in accordance with AMCA 511.

2.7 MATERIALS

- A. Aluminum Extrusions: **ASTM B221 (ASTM B221M)**, Alloy 6063-T5 or T-52.
- B. Aluminum Sheet: **ASTM B209 (ASTM B209M)**, Alloy 3003 or 5005, with temper as required for forming or as otherwise recommended by metal producer for required finish.
- C. Galvanized-Steel Sheet: ASTM A653/A653M, **G90 (Z275)** zinc coating, mill phosphatized.
- D. Stainless Steel Sheet: ASTM A666, Type 304, with No. **[4][6]** finish.
- E. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise

indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.
 2. Use **[Phillips flat][hex-head or Phillips pan]**-head screws for exposed fasteners unless otherwise indicated.
- F. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.
- G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
- B. Secure gravity ventilators to roof curbs with zinc-plated hardware **[, that comply with the wind and seismic fastening requirements]**. Use concealed anchorages where possible. Refer to Section 077200 "Roof Accessories."
- C. Install goosenecks on curb base where throat size exceeds **[9 by 9 inches (230 by 230 mm)]<Insert measurement>**.
- D. Install gravity ventilators with clearances for service and maintenance.
- E. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- F. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 079200 "Joint Sealants" for sealants applied during installation.
- G. Label gravity ventilators according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."
- H. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
- I. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes, so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.
- J. Refer to Section 077200 "Roof Accessories" for flashing and counterflashing of roof curbs.

3.2 DUCT CONNECTIONS

- A. Duct installation and connection requirements are specified in Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts." Drawings indicate general arrangement of ducts and duct accessories.



3.3 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

END OF SECTION 23 37 23 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 37 23 00	23 31 16 23	Fabric Air-Distribution Devices
23 37 23 13	23 31 16 23	Fabric Air-Distribution Devices
23 37 23 13	23 37 23 00	HVAC Gravity Ventilators



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 38 13 00 - COMMERCIAL-KITCHEN HOODS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Commercial-kitchen hoods, Type I.
2. Commercial-kitchen hoods, Type II.

B. Related Requirements:

1. Section 233533 "Listed Kitchen Ventilation System Exhaust Ducts" for fire-rated ducts connecting to kitchen hoods.

1.2 DEFINITIONS

- A. Listed Hood: A hood, factory fabricated and tested for compliance with UL 710 by a testing agency acceptable to authorities having jurisdiction.
- B. Standard Hood: A hood, usually field fabricated, that complies with design, construction, and performance criteria of applicable national and local codes.
- C. Type I Hood: A hood designed for grease exhaust applications.
- D. Type II Hood: A hood designed for heat and steam removal and for other nongrease applications.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [Project site]<Insert location>.

1. Required Attendance:
 - a. <Insert personnel by title>.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Standard hoods.
2. Filters/baffles.
3. Fire-suppression systems.
4. Luminaires.

B. Shop Drawings: Signed and sealed by a qualified professional engineer.

1. Shop Drawing Scale: [1/4 inch = 1 foot (1:50)]<Insert scale>.
2. Show plan view, elevation view, sections, roughing-in dimensions, service requirements, duct

- connection sizes, and attachments to other work.
3. Show cooking equipment plan and elevation to confirm minimum code-required overhang.
4. Indicate performance, exhaust and makeup air airflow, and pressure loss at actual Project-site elevation.
5. Show water-supply and drain piping connections.
6. Show control cabinets.
7. Show fire-protection cylinders, piping, actuation devices, and manual control devices.
8. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
9. Design Calculations: Calculate requirements for selecting seismic restraints.
10. Include diagrams for power, signal, and control wiring.
11. Duct Connections: Detail connections between ducts and hoods, including access doors and panels.
12. Piping Diagrams: Detail fire-suppression piping and components and differentiate between manufacturer-installed and field-installed piping. Include roughing-in requirements for drain connections. Show cooking equipment plan and elevation to illustrate fire-suppression nozzle locations.

- a. Piping Diagram Scale: **[1/4 inch = 1 foot (1:50)]<Insert scale>**.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 1. Coordination Drawing Scale: **[1/4 inch = 1 foot (1:50)]<Insert scale>**.
 2. Suspended ceiling assembly components.
 3. Structural members to which equipment will be attached.
 4. Roof framing and support members for duct penetrations.
 5. Items penetrating finished ceiling including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Moldings on hoods and accessory equipment.
 - g. **<Insert item>**.
- B. Welding certificates.
- C. Seismic Qualification Data: Submit certification that commercial-kitchen hoods, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control reports.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Grease Filters/Baffles: **[One]<Insert number>** complete set(s).

1.7 QUALITY ASSURANCE

- A. Engineering Responsibility: Preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.
- B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D 1.1M, "Structural Welding Code - Steel," for hangers and supports; and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for joint and seam welding.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 HOOD MATERIALS

- A. Stainless-Steel Sheet: ASTM A666, Type 304.
 1. Minimum Thickness: **[0.037 inch (0.94 mm)][0.050 inch (1.3 mm)]<Insert dimension>**.
 2. Finish: Comply with SSINA's "Finishes for Stainless Steel" for recommendations for applying and designating finishes.
 - a. Finish shall be free from tool and die marks and stretch lines and shall have uniform, directionally textured, polished finish indicated, free of cross scratches. Grain shall run with long dimension of each piece.
 3. Concealed Stainless-Steel Surfaces: ASTM A480/A480M, No. 2B finish (bright, cold-rolled, unpolished finish).
 4. Exposed Surfaces: **[ASTM A480/A480M, No. 2B finish (bright, cold-rolled, unpolished)][ASTM A480/A480M, No. 3 finish (intermediate polished surface)][ASTM A480/A480M, No. 4 finish (directional satin)][ASTM A480/A480M, No. 6 finish (dull satin)][ASTM A480/A480M, No. 7 finish (reflective, directional polish)][ASTM A480/A480M, No. 8 finish (mirrorlike reflective, nondirectional polish)]**.
 5. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.



- B. Carbon-Steel Sheets: ASTM A1008/A1008M, cold-rolled sheets; commercial quality; with oiled, exposed matte finish.
 - 1. Minimum Thickness: **[0.043 inch (1.09 mm)][0.0478 inch (1.2 mm)]<Insert dimension>**.
- C. Galvanized-Steel Sheet: Lock-forming quality; ASTM A653/A653M, **G90 (Z275)** coating designation.
 - 1. Minimum Thickness: **[0.052 inch (1.32 mm)]<Insert dimension>**.
- D. Zinc-Coated Steel Shapes: ASTM A36/A36M, zinc coated according to ASTM A123/A123M requirements.
- E. Sealant: ASTM C920; Type S, Grade NS, Class 25, Use NT. Elastomeric sealant shall be NSF certified for commercial-kitchen hood application. Sealants, when cured and washed, shall comply with requirements in 21 CFR 177.2600, for use in areas that come in contact with food.
 - 1. Color: As selected by Architect from manufacturer's full range.
 - 2. Backer Rod: Closed-cell polyethylene, in diameter larger than joint width.
- F. Sound Dampening: NSF-certified, non-absorbent, hard-drying, sound-deadening compound for permanent adhesion to metal in minimum **1/8-inch (3-mm)** thickness that does not chip, flake, or blister.
- G. Gaskets: NSF certified for end-use application indicated; of resilient rubber, neoprene, or PVC that is nontoxic, stable, odorless, nonabsorbent, and unaffected by exposure to foods and cleaning compounds, and that passes testing according to UL 710.

2.3 GENERAL HOOD FABRICATION REQUIREMENTS

- A. Welding: Use welding rod of same composition as metal being welded. Use methods that minimize distortion and develop strength and corrosion resistance of base metal. Make ductile welds free of mechanical imperfections such as gas holes, pits, or cracks.
 - 1. Welded Butt Joints: Full-penetration welds for full-joint length. Make joints flat, continuous, and homogenous with sheet metal without relying on straps under seams, filling in with solder, or spot welding.
 - 2. Grind exposed welded joints flush with adjoining material and polish to match adjoining surfaces.
 - 3. Where fasteners are welded to underside of equipment, finish reverse side of weld smooth and flush.
 - 4. Coat concealed stainless-steel welded joints with metallic-based paint to prevent corrosion.
 - 5. After zinc-coated steel is welded, clean welds and abraded areas and apply SSPC-Paint 20, high-zinc-dust-content, galvanizing repair paint to comply with ASTM A780/A780M.
- B. For metal butt joints, comply with SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines."
- C. Where stainless steel is joined to a dissimilar metal, use stainless-steel welding material or fastening devices.
- D. Form metal with break bends that are not flaky, scaly, or cracked in appearance; where breaks mar uniform surface appearance of material, remove marks by grinding, polishing, and finishing.
- E. Sheared Metal Edges: Finish free of burrs, fins, and irregular projections.

- F. In food zones, as defined in NSF, fabricate surfaces free from exposed fasteners.
- G. Cap exposed fastener threads, including those inside cabinets, with stainless-steel lock washers and stainless-steel cap (acorn) nuts.
- H. Fabricate pipe slots on equipment with turned-up edges sized to accommodate service and utility lines and mechanical connections.
- I. Fabricate enclosures, including panels, housings, and skirts, to conceal service lines, operating components, and mechanical and electrical devices including those inside cabinets unless otherwise indicated.
- J. Fabricate seismic restraints according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines," Appendix A, "Seismic Restraint Details."
- K. Fabricate equipment edges and backsplashes according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines."
- L. Fabricate enclosure panels to ceiling and wall as follows:
 - 1. Fabricate panels on **[one][two][three][four][all exposed]** side(s) with same material as hood, and extend from ceiling to top of hood canopy and from canopy to wall.
 - 2. Wall Offset Spacer: Minimum of **3 inches (75 mm)**.
 - 3. Wall Shelves and Overshelves: Fabricate according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines," with minimum **0.0625-inch- (1.58-mm-)** thick, stainless-steel shelf tops.

2.4 EXHAUST HOOD FABRICATION, TYPE I HOOD

- A. Exhaust Hood Fabricators, Type I Hood:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[CaptiveAire Systems]**
 - b. **[Carrier Global Corporation]**
 - c. **[Duke Manufacturing Company]**
 - d. **[Gaylord Industries, Inc]**
 - e. **[Giles Enterprises, Inc]**
 - f. **[Grease Master]**
 - g. **[Greenheck Fan Corporation]**
 - h. **[Halton Company]**
 - i. **[LCSystems, Inc.]**
 - j. **[Sturdi-Bilt Restaurant Equipment]**
 - k. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CaptiveAire Systems]**
 - b. **[Carrier Global Corporation]**
 - c. **[Duke Manufacturing Company]**

- d. [Gaylord Industries, Inc]
- e. [Giles Enterprises, Inc]
- f. [Grease Master]
- g. [Greenheck Fan Corporation]
- h. [Halton Company]
- i. [LCSysytems, Inc.]
- j. [Sturdi-Bilt Restaurant Equipment]
- k. <Insert manufacturer's name>

- B. Weld all joints exposed to grease with continuous welds, and make filters/baffles or grease extractors and makeup air diffusers easily accessible for cleaning.
1. Fabricate hoods according to NSF 2, "Food Equipment."
 2. Hoods shall be listed and labeled, according to UL 710, by a testing agency acceptable to authorities having jurisdiction.
 3. Hoods shall be designed, fabricated, and installed according to NFPA 96.
 4. Include access panels as required for access to fire dampers and fusible links.
 5. Duct Collars: Minimum **0.0598-inch- (1.5-mm-)** thick steel at least **3 inches (75 mm)** long, continuously welded to top of hood and at corners. **[Fabricate a collar with a 0.5-inch- (13-mm-) wide duct flange.]**
 6. Duct-Collar Fire Dampers: Collar and damper shall comply with UL 710 testing and listing required for the entire hood.
 - a. Collar: Minimum **0.0598-inch- (1.5-mm-)** thick stainless steel, at least **3 inches (75 mm)** long, continuously welded to top of hood and at corners. **[Fabricate a collar with a minimum 0.5-inch- (13-mm-) wide duct flange.]**
 - b. Blades: Minimum **0.1046-inch- (2.7-mm-)** thick stainless steel, counterbalanced to remain closed after actuation.
 - c. Blade Pivot and Spring: Stainless steel.
 - d. Fusible Link: Replaceable, **212 deg F (100 deg C)** rated.
 7. Makeup Air Fire Dampers: Labeled, according to UL 555, by a testing agency acceptable to authorities having jurisdiction.
 - a. Fire Rating: 1-1/2 hours.
 - b. Frame: SMACNA **[Type A][Type B]**, with blades in airstream; fabricated with roll-formed, **[galvanized][stainless]** steel; with mitered and interlocking corners.
 - c. Blades: Roll-formed, interlocking or folded, minimum **0.034-inch- (0.86-mm-)** thick, galvanized-steel sheet.
 - d. Horizontal Dampers: Include a blade lock and stainless-steel closure spring.
 - e. Fusible Link: Replaceable, **[165 deg F (74 deg C)][212 deg F (100 deg C)]** rated.
- C. Hood Configuration: Exhaust **[only][and makeup air]**.
1. Makeup air shall be introduced by **[induction][combination of induction and diffusion]** inside canopy. If makeup air is not heated, insulate interior of makeup air plenum with high-density insulation having maximum flame-spread and smoke-developed indexes of 25 and 50, respectively.
 2. Makeup air shall be introduced through **[front][and][bottom]** of canopy through **[perforated diffusers][supply-air registers with adjustable guide vanes]**.
 3. Makeup air shall be introduced through laminar-flow-type, perforated metal panels on front of hood canopy.
 4. Makeup air shall be introduced through laminar-flow-type, perforated metal diffusers mounted in the ceiling in front of hood canopy. Furnish laminar-flow-type diffusers with baked **[white]<Insert color>** enamel finish and volume-control dampers.

5. Makeup air shall be introduced through plenum at rear of hood, extending down below appliance cooking surfaces.
- D. Hood Style: **[Wall-mounted canopy][Single-island canopy][Double-island canopy][Back shelf][Eyebrow][Pass over]**.
- E. Filters/Baffles: Removable, **[stainless-steel][aluminum], with spring-loaded fastening**. Fabricate stainless steel for filter frame and removable collection cup and pitched trough. Exposed surfaces shall be pitched to drain to collection cup. Filters/baffles shall be tested according to UL 1046, "Safety for Grease Filters for Exhaust Ducts," by an NRTL acceptable to authorities having jurisdiction.
- F. Removable Water-Wash Grease Extractor: Stainless steel, tested with hood according to UL 710.
- G. Stationary Water-Wash Grease Extractor: Integral, automatically self-cleaning, spraying hot water and detergent over the entire length of exhaust plenum. Fabricate to supply **140 deg F (60 deg C)** water at **1.25 gpm/ft. (0.26 L/s per m)** of hood length, at **40- to 60-psig (276- to 414-kPa)** inlet pressure.
 1. Water Piping: ASTM A270/A270M, Type 304 stainless steel.
 2. Fabricate to drain water and detergent to a collection trough having stainless-steel drain fittings.
 3. Single, **[hood][wall]**-mounting control panel with a solid-state, programmable controller shall control all hoods on Project. Wash cycle shall be factory set to operate for 10 minutes after fans stop.
 4. Detergent shall be supplied by an adjustable-flow, 120-V ac injection pump from a reservoir with a minimum capacity of **2.5 gal. (9.5 L)**.
- H. Water-mist option shall supply a maximum of **0.1 gpm/ft. (0.02 L/s per m)** of hood length through stainless-steel piping and nozzles.
 1. Water Piping: ASTM A270/A270M, Type 304 stainless steel.
- I. Luminaires: **[Recessed][Surface-mounted], [LED][fluorescent][incandescent]** luminaires and lamps with lenses sealed vapor tight. Wiring shall be in conduit on hood exterior. Number and location of luminaires shall provide a minimum of **70 fc (753 lx)** at **30 inches (762 mm)** above finished floor.
 1. Light switches shall be mounted **[on front panel of hood canopy][on wall adjacent to hood][in hood control panel]**.
 2. Luminaires: **[LED][Fluorescent][Incandescent]** complying with UL 1598.
- J. Comply with hood control requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- K. Hood Controls: **[Hood][Wall]**-mounting control cabinet, **[factory wired to control groups of adjacent hoods, and]** fabricated of stainless steel.
 1. Exhaust Fan: On-off switches shall start and stop the exhaust fan. **[Interlock exhaust fan with makeup air supply fan to operate simultaneously.]** Interlock exhaust fan with fire-suppression system to operate fan(s) during fire-suppression-agent release and to remain in operation until manually stopped. Include red pilot light to indicate fan operation.
 - a. Exhaust Fan Motor Starter: **[Comply with Section 262913.03 "Manual and Magnetic Motor Controllers."][Fan Motor Starter: Comply with Section 262913.06 "Soft-Start Motor Controllers."]**
 2. Exhaust Fan Interlock: Factory wire the exhaust fan starters in a single control cabinet for adjacent hoods to operate together.
 3. Photocell and Temperature Control, Cycling: Cycle makeup air and exhaust-air fans on and off,

based on temperature at hood discharge and opacity of smoke in hood. Interlock fan control with fire-suppression system to operate during fire-suppression-agent release and to remain in operation until manually stopped. Provide air-purge fan and conduit to photocell and reflector to avoid grease accumulation that will negatively affect performance of system.

4. Photocell and Temperature Control, Two Speed: Change speed (off, low, and high) of makeup air and exhaust-air fans with speed switch, based on temperature at hood discharge and opacity of smoke in hood. Interlock fan control with fire-suppression system to operate at high speed during fire-suppression-agent release and to remain in high-speed operation until manually stopped. Provide air-purge fan and conduit to photocell and reflector to avoid grease accumulation that will negatively affect performance of system. Controller shall limit exhaust-duct velocity between **<Insert minimum velocity>** and **<Insert maximum velocity>**. Controller shall limit supply quantity to **<Insert minimum quantity>** for proper operation of makeup air unit.
5. Photocell and Temperature Control, Variable Speed: Vary speed of makeup air and exhaust-air fans with variable-frequency controllers, based on temperature at hood discharge and opacity of smoke in hood. Interlock fan control with fire-suppression system to operate at high speed during fire-suppression-agent release and to remain in high-speed operation until manually stopped. Provide air-purge fan and conduit to photocell and reflector to avoid grease accumulation that will negatively affect performance of system. Controller shall limit exhaust-duct velocity between **<Insert minimum velocity>** and **<Insert maximum velocity>**. Controller shall limit supply quantity to **<Insert minimum quantity>** for proper operation of makeup air unit.
6. High-Temperature Control: Alarm shall sound and cooking equipment shall shut down before hood discharge temperature rises to actuation temperature of fire-suppression system.
7. Water-Wash Timer: **[24-hour clock][365-day, programmable timer]** shall control sequential wash of multiple hood sections.
8. Water Mist: Solenoid valve interlocked with exhaust fan to open with hood operation.

L. Capacities and Characteristics:

1. Nominal Hood Length: **<Insert inches (mm)>**.
2. Nominal Hood Width: **<Insert inches (mm)>**.
3. Canopy Height: **<Insert inches (mm)>**.
4. Exhaust Airflow: **<Insert cfm (L/s)>**.
5. Exhaust-Air Pressure Loss: **<Insert inches wg (kPa)>**.
6. Makeup Air Airflow: **<Insert cfm (L/s)>**.
7. Makeup Air Pressure Loss: **<Insert inches wg (kPa)>**.
8. Water-Supply Connection: **<Insert NPS (DN)>**.
9. Washdown Water Flow: **<Insert gpm (L/s)>**.
10. Minimum Water Pressure: **<Insert psig (kPa)>**.
11. Mist Water Flow: **<Insert gpm (L/s)>**.
12. Sanitary Drain Connection: **<Insert NPS (DN)>**.

2.5 EXHAUST HOOD FABRICATION, TYPE II HOOD

A. Exhaust Hood Fabricators, Type II Hood:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[CaptiveAire Systems]**
 - b. **[Carrier Global Corporation]**
 - c. **[Duke Manufacturing Company]**
 - d. **[Gaylord Industries, Inc]**

- e. [Giles Enterprises, Inc]
 - f. [Grease Master]
 - g. [Greenheck Fan Corporation]
 - h. [Halton Company]
 - i. [LCSysytems, Inc.]
 - j. [Sturdi-Bilt Restaurant Equipment]
 - k. [Vent Master]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CaptiveAire Systems]
 - b. [Carrier Global Corporation]
 - c. [Duke Manufacturing Company]
 - d. [Gaylord Industries, Inc]
 - e. [Giles Enterprises, Inc]
 - f. [Grease Master]
 - g. [Greenheck Fan Corporation]
 - h. [Halton Company]
 - i. [LCSysytems, Inc.]
 - j. [Sturdi-Bilt Restaurant Equipment]
 - k. [Vent Master]
 - l. <Insert manufacturer's name>
- B. Fabricate hoods according to NSF 2, "Food Equipment."
 - C. Fabricate hoods to comply with SMACNA's "HVAC Duct Construction Standards: Metal and Flexible."
 - D. Hood Configuration: Exhaust **[only][and makeup air]**.
 1. Makeup air shall be introduced by **[induction][combination of induction and diffusion]** inside canopy. If makeup air is not heated, insulate interior of makeup air plenum with high-density insulation having maximum flame-spread and smoke-developed indexes of 25 and 50, respectively.
 2. Makeup air shall be introduced through **[front][and][bottom]** of canopy through supply-air registers.
 3. Makeup air shall be introduced through laminar-flow-type, perforated metal panels on front of hood canopy.
 4. Makeup air shall be introduced through plenum at rear of hood, extending down below appliance cooking surfaces.
 - E. Hood Type: **[Heat and vapor][Condensate]** removal.
 - F. Hood Style: **[Wall-mounted canopy][Single-island canopy][Double-island canopy][Back shelf][Eyebrow][Pass over]**.
 - G. Condensate Hood Baffles: Removable, stainless-steel baffles to drain into a hood drain trough, and stainless-steel drain piping.
 - H. Luminaires: **[Recessed][Surface-mounted]**, **[LED][fluorescent][incandescent]** luminaires and lamps with lenses sealed vapor tight. Wiring shall be installed in stainless-steel conduit on hood exterior. Number and location of luminaires shall provide a minimum of **70 fc (753 lx) at 30 inches (762 mm)** above finished floor.

1. Light switches shall be mounted [on front panel of hood canopy][on wall adjacent to hood][in hood control panel].
2. Luminaires: [LED][Fluorescent][Incandescent] complying with UL 1598.

I. Capacities and Characteristics:

1. Nominal Hood Length: <Insert inches (mm)>.
2. Nominal Hood Width: <Insert inches (mm)>.
3. Canopy Height: <Insert inches (mm)>.
4. Exhaust Airflow: <Insert cfm (L/s)>.
5. Exhaust-Air Pressure Loss: <Insert inches wg (kPa)>.
6. Makeup Air Airflow: <Insert cfm (L/s)>.
7. Makeup Air Pressure Loss: <Insert inches wg (kPa)>.

2.6 FIRE-SUPPRESSION SYSTEM, WET CHEMICAL

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Ansul; brand of Johnson Controls International plc, Building Solutions North America]
2. [Badger Fire Protection; a Carrier company]
3. [Kidde; Carrier Global Corporation]
4. [Pyro-Chem; brand of Johnson Controls International plc, Building Solutions North America]
5. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Ansul; brand of Johnson Controls International plc, Building Solutions North America]
2. [Badger Fire Protection; a Carrier company]
3. [Kidde; Carrier Global Corporation]
4. [Pyro-Chem; brand of Johnson Controls International plc, Building Solutions North America]
5. <Insert manufacturer's name>

C. Description: Engineered distribution piping designed for automatic detection and release or manual release of fire-suppression agent by hood operator. Fire-suppression system shall be listed and labeled for complying with NFPA 17A, "Wet Chemical Extinguishing Systems," by a qualified testing agency acceptable to authorities having jurisdiction.

1. Steel Pipe, **NPS 2 (DN 50)** and Smaller: ASTM A53/A53M, Type S, Grade A, Schedule 40, plain ends.
2. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.
3. Piping, fusible links and release mechanism, tank containing the suppression agent, and controls shall be factory installed. Controls shall be in stainless-steel control cabinet mounted on [hood][or][wall]. Furnish manual pull station for wall mounting. Exposed piping shall be covered with chrome-plated aluminum tubing. Exposed fittings shall be chrome plated.
4. Liquid Extinguishing Agent: Noncorrosive, low-pH liquid.
5. Furnish electric-operated gas shutoff valve; see [Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping."]
6. Furnish electric-operated gas shutoff valve with clearly marked open and closed indicator for field installation.

7. Fire-suppression system controls shall be integrated with controls for fans, lights, and fuel supply and located in a single cabinet for each group of hoods immediately adjacent.
8. Wiring shall have color-coded, numbered terminal blocks and grounding bar. Spare terminals for fire alarm, optional wiring to start fan with fire alarm, red pilot light to indicate fan operation, and control switches shall all be factory wired in control cabinet with relays or starters. Include spare terminals for fire alarm, and wiring to start fan with fire alarm.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before equipment installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Coordinate equipment layout and installation with adjacent Work, including luminaires, HVAC equipment, plumbing, and fire-suppression system components.
- B. Complete field assembly of hoods where required.
 1. Make closed butt and contact joints that do not require filler.
 2. Grind field welds on stainless-steel equipment smooth, and polish to match adjacent finish. Comply with welding requirements in "General Hood Fabrication Requirements" Article.
- C. Install hoods and associated services with clearances and access for maintaining, cleaning, and servicing hoods, filters/baffles, grease extractor, and fire-suppression systems according to manufacturer's written instructions and requirements of authorities having jurisdiction.
- D. Make cutouts in hoods where required to run service lines and to make final connections, and seal openings according to UL 1978.
- E. Securely anchor and attach items and accessories to walls, floors, or bases with stainless-steel fasteners unless otherwise indicated.
- F. Install hoods to operate free from vibration.
- G. Install seismic restraints according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines," Appendix A, "Seismic Restraint Details."
- H. Install trim strips and similar items requiring fasteners in a bed of sealant. Fasten with stainless-steel fasteners at **48 inches (1200 mm)** o.c. maximum.
- I. Install sealant in joints between equipment and abutting surfaces with continuous joint backing unless otherwise indicated. Provide airtight, watertight, vermin-proof, sanitary joints.
- J. Install lamps, with maximum recommended wattage, in equipment with integral lighting.

- K. Set initial temperatures, and calibrate sensors.
- L. Set field-adjustable switches.

3.3 CONNECTIONS

- A. Where installing piping adjacent to hoods, allow space for service and maintenance.
- B. Install reduced-pressure backflow preventer on washer-water supply. Backflow preventer is specified in Section 221119 "Domestic Water Piping Specialties."
- C. Install washer-water drain piping full size of hood connection to an adjacent floor drain or a floor sink.
- D. Makeup Water Connection: Comply with applicable requirements for valves and accessories on piping connections to water-cooled units in Section 221119 "Domestic Water Piping Specialties."
- E. Connect ducts according to requirements in Section 233300 "Air Duct Accessories." Install flexible connectors on makeup air supply duct. Weld exhaust-duct connections with continuous liquidtight joint.
- F. Install fire-suppression piping for remote-mounted suppression systems according to NFPA 17A, "Wet Chemical Extinguishing Systems."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Test each equipment item for proper operation. Repair or replace equipment that is defective, including units that operate below required capacity or that operate with excessive noise or vibration.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Test water, drain, gas, and liquid-carrying components for leaks. Repair or replace leaking components.
 - 4. Perform hood performance tests required by authorities having jurisdiction.
 - 5. Perform fire-suppression system performance tests required by authorities having jurisdiction.
- D. Commercial-kitchen hoods will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain commercial-kitchen hoods.



END OF SECTION 23 38 13 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 38 13 13	23 38 13 00	Commercial-Kitchen Hoods
23 38 13 16	11 40 00 00	Foodservice Equipment
23 38 13 16	23 31 13 00	Metal Ducts
23 38 13 16	23 37 23 00	HVAC Gravity Ventilators
23 38 13 16	23 38 13 00	Commercial-Kitchen Hoods



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 41 00 00 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal panel filters.
2. Flat panel filters.
3. Pleated panel filters.
4. Ring panel filters.
5. Nonsupported bag filters.
6. Supported bag filters.
7. Rigid cell box filters.
8. V-bank cell filters.
9. Self-supported pocket filters.
10. Bulk media.
11. Front- or back-access filter frames.
12. Side-access filter housings.
13. Filter gauges.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for particulate air filters.
2. Section 233400 "HVAC Fans" for customized fan and filter units.
3. Section 234133 "High-Efficiency Particulate Air Filtration" for HEPA filters used in combination with particulate air filters.
4. Section 234300 "Electronic Air Cleaners" for electronic units combined with particulate filters as part of a system.

1.2 DEFINITIONS

- A. HIPS:** High-impact polystyrene.

1.3 ACTION SUBMITTALS

- A. Product Data:** For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
- B. Sustainable Design Submittals:**
1. Product data showing compliance with ASHRAE 62.1.
- C. Shop Drawings:** For air filters. Include plans, elevations, sections, details, and attachments to other work.
1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.

2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for filters, accessories, and components from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Test Reports: For each filter, for tests performed by **[manufacturer and witnessed by a qualified testing agency][a qualified testing agency]**.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Provide **[one]<Insert number>** complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.
 2. Provide **[one]<Insert number>** container(s) of red oil for inclined manometer filter gauge.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean, dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove

- just prior to operating unit.
2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
3. Replace installed products damaged during construction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Filters shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- B. ASHRAE Compliance:
 1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
 2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
- C. Comply with NFPA 90A and NFPA 90B.
- D. Comply with UL 900.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 METAL PANEL FILTERS

- A. Description: Factory-fabricated, self-supported, cleanable, all-metal, impingement-type, panel-type, permanent air filters with holding frames.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Columbus Industries, Inc]**
 4. **[Filtration Group]**
 5. **[Koch Filter Corporation]**
 6. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 7. **[Tri-Dim Filter Corporation]**
 8. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's**

name; product name or designation> or comparable product by one of the following:

1. **[AAF International]**
2. **[Camfil Farr Inc.]**
3. **[Columbus Industries, Inc]**
4. **[Filtration Group]**
5. **[Koch Filter Corporation]**
6. **[Parker Hannifin Corporation; HVAC Filtration Division]**
7. **[Tri-Dim Filter Corporation]**
8. **<Insert manufacturer's name>**

D. Source Limitations: Obtain from single source from single manufacturer.

E. Capacities and Characteristics:

1. Drawing Tag No.: **<Insert designation>**.
2. Face Size: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
3. Depth: **<Insert number> inches (mm) nominal**.
4. Number of Filters, Wide by High: **<Insert number wide by number high>**.
5. System Airflow: **<Insert number> cfm (L/s)**.
6. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s)**.
7. Initial Resistance: **<Insert number> inches wg (Pa)**.
8. Recommended Final Resistance: **<Insert number> inches wg (Pa)**.
9. Access: **[Front][Back][Side]**.

F. Media: Minimum of **[three][four]<Insert number>** alternate layers of **[galvanized-steel][aluminum][stainless steel]** flat and herringbone or serpentine-crimp mesh screen.

1. Non-oiled for grease removal application.
2. Adhesive coating.

G. Filter-Media Frame: **[Galvanized steel][Hot-dip galvanized steel][Aluminum][Stainless steel]**, hinged, and with pull and retaining handles fastened to the media.

1. Drain holes.

H. Efficiency: Minimum **[90]<Insert number>** percent efficiency on particles **[10]<Insert number>** microns and larger.

2.3 FLAT PANEL FILTERS

A. Description: Factory-fabricated, self-supported, flat, nonpleated, panel-type, disposable air filters with holding frames.

B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[AAF International]**
2. **[Columbus Industries, Inc]**
3. **[Flanders Corporation]**
4. **[Glasfloss Industries]**
5. **[Koch Filter Corporation]**
6. **[Parker Hannifin Corporation; HVAC Filtration Division]**

7. [Tri-Dim Filter Corporation]
 8. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [AAF International]
 2. [Columbus Industries, Inc]
 3. [Flanders Corporation]
 4. [Glasfloss Industries]
 5. [Koch Filter Corporation]
 6. [Parker Hannifin Corporation; HVAC Filtration Division]
 7. [Tri-Dim Filter Corporation]
 8. <Insert manufacturer's name>
- D. Source Limitations: Obtain from single source from single manufacturer.
- E. Capacities and Characteristics:
1. Drawing Tag No.: <Insert designation>.
 2. Face Size: [24 by 24 inches (600 by 600 mm)]<Insert dimensions>.
 3. Depth: [4 inches (100 mm)]<Insert dimension> nominal.
 4. Number of Filters, Wide by High: <Insert number wide by number high>.
 5. System Airflow: <Insert number> cfm (L/s).
 6. Maximum or Rated Face Velocity: <Insert number> fpm (m/s).
 7. Initial Resistance: [0.45-inch wg (112 Pa)]<Insert value> at [500 fpm (2.5 m/s)]<Insert value>.
 8. Recommended Final Resistance: <Insert number> inches wg (Pa).
 9. Minimum Efficiency Reporting Value and Average Arrestance: MERV [4]<Insert value>, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" and "Average Arrestance" according to ASHRAE 52.2.
 10. Minimum Efficiency Reporting Value: MERV [6]<Insert value>, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
 11. Access: [Front][Back][Side].
- F. Media: [Interlaced glass or][Cotton and] synthetic fibers coated with nonflammable adhesive.
1. Media shall be coated with an antimicrobial agent.
 2. Metal Retainer: Upstream side and downstream side.
- G. Filter-Media Frame: [Cardboard with perforated metal retainer][Galvanized steel with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles] sealed or bonded to the media.
- 2.4 PLEATED PANEL FILTERS
- A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
- B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [3M]
 2. [AAF International]
 3. [Air-Nu]

4. [Camfil Farr Inc.]
 5. [Columbus Industries, Inc]
 6. [Filtration Group]
 7. [Flanders Corporation]
 8. [Glasfloss Industries]
 9. [Koch Filter Corporation]
 10. [Parker Hannifin Corporation; HVAC Filtration Division]
 11. [Tri-Dim Filter Corporation]
 12. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [3M]
 2. [AAF International]
 3. [Air-Nu]
 4. [Camfil Farr Inc.]
 5. [Columbus Industries, Inc]
 6. [Filtration Group]
 7. [Flanders Corporation]
 8. [Glasfloss Industries]
 9. [Koch Filter Corporation]
 10. [Parker Hannifin Corporation; HVAC Filtration Division]
 11. [Tri-Dim Filter Corporation]
 12. <Insert manufacturer's name>
- D. Source Limitations: Obtain from single source from single manufacturer.
- E. Capacities and Characteristics:
1. Drawing Tag No.: <Insert designation>.
 2. Face Size: [24 by 24 inches (600 by 600 mm)]<Insert dimensions>.
 3. Depth: [1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)]<Insert dimension> nominal.
 4. Number of Filters, Wide by High: <Insert number wide by number high>.
 5. System Airflow: <Insert number> cfm (L/s).
 6. Maximum or Rated Face Velocity: <Insert number> fpm (m/s).
 7. Initial Resistance: [0.25-inch wg (62 Pa)][0.35-inch wg (87.2 Pa)][0.45-inch wg (112 Pa)][0.60-inch wg (150 Pa)]<Insert value> at [350 fpm (1.8 m/s)][500 fpm (2.5 m/s)]<Insert value>.
 8. Recommended Final Resistance: <Insert number> inches wg (Pa).
 9. Minimum Efficiency Reporting Value: MERV [6][13]<Insert value>, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
 10. Access: [Front][Back][Side].
- F. Media: [Interlaced glass or][Cotton and] synthetic fibers coated with nonflammable adhesive.[Coat media with an antimicrobial agent.]
1. Separators shall be bonded to the media to maintain pleat configuration.
 2. Welded-wire grid shall be on downstream side to maintain pleat.
 3. Media shall be bonded to frame to prevent air bypass.
 4. Support members on upstream and downstream sides to maintain pleat spacing.
- G. Filter-Media Frame: [Cardboard frame with perforated metal retainer][Galvanized steel][Aluminized steel][with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles] sealed or bonded to the media.

2.5 RING PANEL FILTERS

- A. Description: Internally supported, flat panel filters for installation in a filter track.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Columbus Industries, Inc]**
 2. **[Filtration Group]**
 3. **[Flanders Corporation]**
 4. **[Glasfloss Industries]**
 5. **[Koch Filter Corporation]**
 6. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 7. **[Tri-Dim Filter Corporation]**
 8. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Columbus Industries, Inc]**
 2. **[Filtration Group]**
 3. **[Flanders Corporation]**
 4. **[Glasfloss Industries]**
 5. **[Koch Filter Corporation]**
 6. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 7. **[Tri-Dim Filter Corporation]**
 8. **<Insert manufacturer's name>**
- D. Source Limitations: Obtain from single source from single manufacturer.
- E. Capacities and Characteristics:
1. Drawing Tag No.: **<Insert designation>**.
 2. Face Size: **<Insert number> inches (mm)**.
 3. Depth: **[1-1/2 inches (38 mm)][1-3/4 inches (44 mm)][2 inches (50 mm)]<Insert dimension>**.
 4. Number of Filters, Wide by High: **<Insert number wide by number high>**.
 5. System Airflow: **<Insert number> cfm (L/s)**.
 6. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s)**.
 7. Initial Resistance: **<Insert number> inches wg (Pa)**.
 8. Recommended Final Resistance: **<Insert number> inches wg (Pa)**.
 9. Minimum Efficiency Reporting Value: MERV **[6]<Insert value>**, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
 10. Access: Side.
 11. Media: **[Two][Three][Four]<Insert number>-ply polyester with sealed edges.[Coat with antimicrobial agent.]**
 12. Panel Construction: **[Single][with one edge unsealed for support removal][Linked]**.
- F. Internal Support: 9-gauge steel-wire frame.

2.6 NONSUPPORTED BAG FILTERS

- A. Description: Factory-fabricated, dry, extended-surface, nonsupported filters with header frames.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide**

products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. **[AAF International]**
2. **[Air-Nu]**
3. **[Camfil Farr Inc.]**
4. **[Columbus Industries, Inc]**
5. **[Filtration Group]**
6. **[Glasfloss Industries]**
7. **[Koch Filter Corporation]**
8. **[Parker Hannifin Corporation; HVAC Filtration Division]**
9. **[Tri-Dim Filter Corporation]**
10. **<Insert manufacturer's name>**

C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[AAF International]**
2. **[Air-Nu]**
3. **[Camfil Farr Inc.]**
4. **[Columbus Industries, Inc]**
5. **[Filtration Group]**
6. **[Glasfloss Industries]**
7. **[Koch Filter Corporation]**
8. **[Parker Hannifin Corporation; HVAC Filtration Division]**
9. **[Tri-Dim Filter Corporation]**
10. **<Insert manufacturer's name>**

D. Source Limitations: Obtain from single source from single manufacturer.

E. Capacities and Characteristics:

1. Drawing Tag No.: **<Insert designation>**.
2. Face Size: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
3. Depth: **[12 inches (300 mm)][22 inches (550 mm)][30 inches (750 mm)]<Insert dimension>**.
4. Number of Filters, Wide by High: **<Insert number wide by number high>**.
5. Surface Area: **<Insert number> sq. ft. (sq. m)**.
6. System Airflow: **<Insert number> cfm (L/s)**.
7. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s)**.
8. Initial Resistance: **<Insert number> inches wg (Pa)**.
9. Recommended Final Resistance: **<Insert number> inches wg (Pa)**.
10. Minimum Efficiency Reporting Value: MERV **[11][13][15]<Insert value>**, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
11. Access: **[Front][Back][Side]**.

F. Media: **[Glass-fiber][Synthetic]** material constructed so individual pockets are maintained in tapered form under rated-airflow conditions by flexible internal supports. **[Coat media with an antimicrobial agent.]**

G. Filter-Media Frame: **[Galvanized steel]<Insert material>**.

2.7 SUPPORTED BAG FILTERS

- A. Description: Factory-fabricated, dry, extended surface, self-supported filters with holding frames in steel, basket-type retainer, internal metal grid retainer, or self-supporting media pockets.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[AAF International]**
 - 2. **[Air-Nu]**
 - 3. **[Camfil Farr Inc.]**
 - 4. **[Columbus Industries, Inc]**
 - 5. **[Filtration Group]**
 - 6. **[Glasfloss Industries]**
 - 7. **[Koch Filter Corporation]**
 - 8. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 - 9. **[Tri-Dim Filter Corporation]**
 - 10. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[AAF International]**
 - 2. **[Air-Nu]**
 - 3. **[Camfil Farr Inc.]**
 - 4. **[Columbus Industries, Inc]**
 - 5. **[Filtration Group]**
 - 6. **[Glasfloss Industries]**
 - 7. **[Koch Filter Corporation]**
 - 8. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 - 9. **[Tri-Dim Filter Corporation]**
 - 10. **<Insert manufacturer's name>**
- D. Source Limitations: Obtain from single source from single manufacturer.
- E. Capacities and Characteristics:
 - 1. Drawing Tag No.: **<Insert designation>**.
 - 2. Face Size: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
 - 3. Depth: **[12 inches (300 mm)][22 inches (550 mm)][30 inches (750 mm)]<Insert dimension>**.
 - 4. Number of Filters, Wide by High: **<Insert number wide by number high>**.
 - 5. Surface Area: **<Insert number> sq. ft. (sq. m)**.
 - 6. System Airflow: **<Insert number> cfm (L/s)**.
 - 7. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s)**.
 - 8. Initial Resistance: **<Insert number> inches wg (Pa)**.
 - 9. Recommended Final Resistance: **<Insert number> inches wg (Pa)**.
 - 10. Minimum Efficiency Reporting Value: MERV **[11][13][15]<Insert value>**, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
 - 11. Access: **[Front][Back][Side]**.
- F. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports. **[Coat media with an antimicrobial agent.]**
- G. Filter-Media Frame: **[Galvanized steel]<Insert material>**.

2.8 RIGID CELL BOX FILTERS

- A. Description: Factory-fabricated, **[adhesive-coated]**, disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Air-Nu]**
 2. **[Camfil Farr Inc.]**
 3. **[Columbus Industries, Inc]**
 4. **[Filtration Group]**
 5. **[Flanders Corporation]**
 6. **[Glasfloss Industries]**
 7. **[Koch Filter Corporation]**
 8. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 9. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Air-Nu]**
 2. **[Camfil Farr Inc.]**
 3. **[Columbus Industries, Inc]**
 4. **[Filtration Group]**
 5. **[Flanders Corporation]**
 6. **[Glasfloss Industries]**
 7. **[Koch Filter Corporation]**
 8. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 9. **<Insert manufacturer's name>**
- D. Source Limitations: Obtain from single source from single manufacturer.
- E. Capacities and Characteristics:
1. Drawing Tag No.: **<Insert designation>**.
 2. Face Size: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
 3. Depth: **<Insert number> inches (mm) nominal**.
 4. Number of Filters, Wide by High: **<Insert number wide by number high>**.
 5. Surface Area: **<Insert number> sq. ft. (sq. m)**.
 6. System Airflow: **<Insert number> cfm (L/s)**.
 7. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s)**.
 8. Initial Resistance: **<Insert number> inches wg (Pa)**.
 9. Recommended Final Resistance: **<Insert number> inches wg (Pa)**.
 10. Minimum Efficiency Reporting Value: MERV **[9][11][13][14]<Insert value>**, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
 11. Access: **[Front][Back][Side]**.
- F. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports. **[Coat media with antimicrobial agent]**.
- G. Filter-Media Frames: **[Galvanized steel]<Insert material>**.

2.9 V-BANK CELL FILTERS

- A. Description: Factory-fabricated, **[adhesive-coated,]**disposable, packaged air filters with media angled to airflow, and with holding frames.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[3M]**
 2. **[AAF International]**
 3. **[Camfil Farr Inc.]**
 4. **[Columbus Industries, Inc]**
 5. **[Flanders Corporation]**
 6. **[Glasfloss Industries]**
 7. **[Koch Filter Corporation]**
 8. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 9. **[Tri-Dim Filter Corporation]**
 10. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[3M]**
 2. **[AAF International]**
 3. **[Camfil Farr Inc.]**
 4. **[Columbus Industries, Inc]**
 5. **[Flanders Corporation]**
 6. **[Glasfloss Industries]**
 7. **[Koch Filter Corporation]**
 8. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 9. **[Tri-Dim Filter Corporation]**
 10. **<Insert manufacturer's name>**
- D. Source Limitations: Obtain from single source from single manufacturer.
- E. Capacities and Characteristics:
1. Drawing Tag No.: **<Insert designation>**.
 2. Face Size: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
 3. Depth: **<Insert number> inches (mm) nominal**.
 4. Surface Area: **<Insert number> sq. ft. (sq. m)**.
 5. Number of Filters, Wide by High: **<Insert number wide by number high>**.
 6. System Airflow: **<Insert number> cfm (L/s)**.
 7. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s)**.
 8. Initial Resistance: **<Insert number> inches wg (Pa)**.
 9. Recommended Final Resistance: **<Insert number> inches wg (Pa)**.
 10. Minimum Efficiency Reporting Value: MERV **[11][13][14][15]<Insert number>**, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
 11. Access: **[Front][Back][Side]**.
- F. Media: Fibrous material constructed so individual mini-pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports. **[Coat media with an antimicrobial agent.]**
- G. Filter-Media Frames: **[HIPS]<Insert material>**.

2.10 SELF-SUPPORTED POCKET FILTERS

- A. Description: Factory-fabricated, panel-type, disposable air filters with contoured, self-supported media for extended surface.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[AAF International]**
 2. **[Columbus Industries, Inc]**
 3. **[Filtration Group]**
 4. **[Koch Filter Corporation]**
 5. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 6. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[AAF International]**
 2. **[Columbus Industries, Inc]**
 3. **[Filtration Group]**
 4. **[Koch Filter Corporation]**
 5. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 6. **<Insert manufacturer's name>**
- D. Source Limitations: Obtain from single source from single manufacturer.
- E. Capacities and Characteristics:
1. Drawing Tag No.: **<Insert designation>**.
 2. Face Size: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
 3. Depth: **<Insert number> inches (mm) nominal**.
 4. Number of Filters, Wide by High: **<Insert number wide by number high>**.
 5. Surface Area: **<Insert number> sq. ft. (sq. m)**.
 6. System Airflow: **<Insert number> cfm (L/s)**.
 7. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s)**.
 8. Initial Resistance: **<Insert number> inches wg (Pa)**.
 9. Recommended Final Resistance: **<Insert number> inches wg (Pa)**.
 10. Minimum Efficiency Reporting Value: MERV **[6][8]<Insert value>**, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
 11. Access: **[Front][Back][Side]**.
- F. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports. **[Coat media with an antimicrobial agent.]**
- G. Configuration: **[Single-pocket cube][Multipocket]**.
- H. Filter-Media Frame: **[Galvanized steel]<Insert material>**.

2.11 BULK MEDIA

- A. Description: Air-filter media, factory custom cut or rolled.

- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[AAF International]**
 2. **[Air-Nu]**
 3. **[Columbus Industries, Inc]**
 4. **[Filtration Group]**
 5. **[Glasfloss Industries]**
 6. **[Koch Filter Corporation]**
 7. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 8. **[Tri-Dim Filter Corporation]**
 9. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[AAF International]**
 2. **[Air-Nu]**
 3. **[Columbus Industries, Inc]**
 4. **[Filtration Group]**
 5. **[Glasfloss Industries]**
 6. **[Koch Filter Corporation]**
 7. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 8. **[Tri-Dim Filter Corporation]**
 9. **<Insert manufacturer's name>**
- D. Source Limitations: Obtain from single source from single manufacturer.
- E. Capacities and Characteristics:
1. Thickness: **<Insert number> inches (mm)**.
 2. System Airflow: **<Insert number> cfm (L/s)**.
 3. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s)**.
 4. Initial Resistance: **<Insert number> inches wg (Pa)**.
 5. Recommended Final Resistance: **<Insert number> inches wg (Pa)**.
 - a. Minimum Efficiency Reporting Value and Average Arrestance: MERV **[4]<Insert number>**, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" and "Average Arrestance" according to ASHRAE 52.2.
 6. Minimum Efficiency Reporting Value: MERV **[6][8]<Insert value>**, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
- F. Media: **[Spun glass][Synthetic][Polyester], [in a roll][cut into pads]**.
1. Pad Dimensions: **<Insert number> inches (mm) by <Insert number> inches (mm)**.

2.12 FRONT- OR BACK-ACCESS FILTER FRAMES

- A. Description: **[Galvanized-steel][Aluminum]** framing members with access for either upstream (front) or downstream (back) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with filter installation or operation.



- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[AAF International]**
 2. **[Flanders Corporation]**
 3. **[Koch Filter Corporation]**
 4. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 5. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[AAF International]**
 2. **[Flanders Corporation]**
 3. **[Koch Filter Corporation]**
 4. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 5. **<Insert manufacturer's name>**
- D. Source Limitations: Obtain from single source from single manufacturer.
- E. Prefilters: Incorporate a separate track **[with spring clips]**, removable from front **[or back]**.
- F. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.

2.13 SIDE-ACCESS FILTER HOUSINGS

- A. Description: Factory-assembled, side-service housings, constructed of **[galvanized steel][aluminum]**, with flanges to connect to duct or casing system.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Flanders Corporation]**
 4. **[Koch Filter Corporation]**
 5. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 6. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Flanders Corporation]**
 4. **[Koch Filter Corporation]**
 5. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 6. **<Insert manufacturer's name>**
- D. Source Limitations: Obtain from single source from single manufacturer.

- E. Prefilters: Integral tracks to accommodate [2-inch- (50-mm-)]<Insert dimension> thick, disposable [or washable] filters.
- F. Access Doors: [Hinged, with continuous][Continuous] gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.
- G. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

2.14 FILTER GAUGES

- A. Diaphragm-type gauge with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
- B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. [Dwyer Instruments, Inc]
 - 2. [Parker Hannifin Corporation; HVAC Filtration Division]
 - 3. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. [Dwyer Instruments, Inc]
 - 2. [Parker Hannifin Corporation; HVAC Filtration Division]
 - 3. <Insert manufacturer's name>
- D. Source Limitations: Obtain from single source from single manufacturer.
- E. Diameter: [4-1/2 inches (115 mm)][2 inches (50 mm)].
- F. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).
- G. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).
- H. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).
- I. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: 0- to 3.0-inch wg (0 to 750 Pa).
- J. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: 0- to 4.0-inch wg (0 to 1000 Pa).
- K. Manometer-Type Filter Gauge: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg (0 to 750 Pa), and accurate within 3 percent of the full-scale range.
- L. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF FILTERS

- A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
- B. Install filters in position to prevent passage of unfiltered air.
- C. Install filter gauge for each filter bank.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- E. Coordinate filter installations with duct and air-handling-unit installations.

3.3 INSTALLATION OF FILTER GAUGES

- A. Install filter gauge for each filter bank.
- B. Install filter-gauge, static-pressure taps upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between pressure sensors and **[DDC system]<Insert system description>**.
- C. Connect control wiring between controlled devices.
- D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.



- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 - 1. Test for leakage of unfiltered air while system is operating.
- E. Air filter will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.6 CLEANING

- A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 23 41 00 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 41 13 00	23 41 00 00	Particulate Air Filtration
23 41 13 00	23 42 00 00	Gas-Phase Air Filtration
23 41 13 00	23 43 00 00	Electronic Air Cleaners
23 41 16 00	23 41 00 00	Particulate Air Filtration
23 41 16 00	23 43 00 00	Electronic Air Cleaners
23 41 19 00	23 41 00 00	Particulate Air Filtration
23 41 19 00	23 43 00 00	Electronic Air Cleaners



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 41 33 00 - HIGH-EFFICIENCY PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. HEPA rigid-cell box filters.
2. HEPA V-bank cell filters.
3. HEPA filter diffusers.
4. HEPA filter fan modules.
5. ULPA filters.
6. 95 percent DOP filters.
7. HEPA/ULPA filter holding frames.
8. Side-access HEPA/ULPA filter housings.
9. Side-access HEPA/ULPA filter containment housings.
10. HEPA, ULPA, and 95 percent DOP filter gauges.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for HEPA filters.
2. Section 234100 "Particulate Air Filtration" for particulate-air filters used in combination with HEPA filters.

1.2 DEFINITIONS

- A. DOP: Dioctyl phthalate.
- B. HEPA: High-efficiency particulate air.
- C. PAO: Poly-alpha-olefin.
- D. PSL: Polystyrene latex.
- E. ULPA: Ultralow penetration air.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
- B. Sustainable Design Submittals:
1. Product data showing compliance with ASHRAE 62.1.
- C. Shop Drawings: For air filters.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
3. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for filters, accessories, and components from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Test Reports: For each filter, for tests performed by **[manufacturer and witnessed by a qualified testing agency][a qualified testing agency]**.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Provide **[one]<Insert number>** complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean, dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.



1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
3. Replace installed products damaged during construction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Filters shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- B. ASHRAE 62.1 Compliance:
1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
- C. Comply with NFPA 90A and NFPA 90B.
- D. Comply with UL 900.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended use.
- F. Capacities and Characteristics:
1. Drawing Tag No.: **<Insert designation>**.
 2. Face Size: **[24 by 24 inches (600 by 600 mm)][24 by 12 inches (600 by 300 mm)][12 by 24 inches (300 by 600 mm)]<Insert dimensions>**.
 3. Depth: **<Insert number> inches (mm) nominal**.
 4. Surface Area: **<Insert number> sq. ft. (sq. m)**.
 5. Number of Filters, Wide by High: **<Insert number wide by number high>**.
 6. System Airflow: **<Insert number> cfm (L/s)**.
 7. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s)**.
 8. Initial Resistance: **<Insert number> inches wg (Pa)**.
 9. Recommended Final Resistance: **<Insert number> inches wg (Pa)**.
 10. Access: **[Front][Back][Side]**.
 11. Performance Level: **[99.97 percent HEPA][99.9997 percent ULPA][95 percent DOP]<Insert requirement>**.

2.2 HEPA RIGID-CELL BOX FILTERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be**

incorporated into the Work include, but are not limited to, the following]:

1. [AAF International]
2. [Air-Nu]
3. [Camfil Farr Inc.]
4. [Flanders Corporation]
5. [Glasfloss Industries]
6. [Parker Hannifin Corporation; HVAC Filtration Division]
7. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [AAF International]
2. [Air-Nu]
3. [Camfil Farr Inc.]
4. [Flanders Corporation]
5. [Glasfloss Industries]
6. [Parker Hannifin Corporation; HVAC Filtration Division]
7. <Insert manufacturer's name>

C. Source Limitations: Obtain from single source from single manufacturer.

D. Description: Factory-fabricated, disposable, packaged air filters with media perpendicular to airflow and with holding frames.

E. Standards:

1. Comply with IEST-RP-CC001.6.
2. Comply with UL 586.
3. Comply with IEST-RP-CC034.4.

F. Media: Fibrous material, constructed so individual pleats are maintained under rated-airflow conditions.

1. Internal Separators: [None][Corrugated aluminum]<Insert type>.
2. Media to Filter Frame Seal Material: [Polyurethane]<Insert material>.
3. Faceguard Material: [Aluminum][Stainless steel]<Insert material>.
4. Faceguard Location: [None][Upstream][and][downstream].

G. Filter-Media Frames:

1. Material: [Fire-retardant plywood][Aluminum][Fire-retardant particleboard][Galvanized steel][Non-fire-retardant particleboard]<Insert material>.
2. Filter Frame to Mounting Frame Seal Material: [Neoprene][Knife edge in silicone gel-filled channel][Knife edge in urethane gel-filled channel]<Insert material>.
3. Filter Frame to Mounting Frame Seal Location: [Upstream][Downstream].
4. Style: [Box][Gel track]<Insert style>.

2.3 HEPA V-BANK CELL FILTERS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Flanders Corporation]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Flanders Corporation]**
 4. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain from single source from single manufacturer.
- D. Description: Factory-fabricated, disposable, packaged air filters with media at an angle to airflow and with holding frames.
- E. Standards:
1. Comply with IEST-RP-CC001.6.
 2. Comply with UL 586.
 3. Comply with IEST-RP-CC034.4.
- F. Media: Fibrous material, constructed so individual pleats are maintained under rated-airflow conditions.
1. Internal Separators: **[None][Corrugated aluminum]<Insert type>**.
 2. Media to Filter Frame Seal Material: **[Polyurethane]<Insert sealant>**.
- G. Filter-Media Frames:
1. Material: **[Fire-retardant plywood][Aluminum][Fire-retardant particleboard][Galvanized steel][Non-fire-retardant particleboard]<Insert material>**.
 2. Filter Frame to Mounting Frame Seal Material: **[Neoprene][Knife edge in silicone gel-filled channel][Knife edge in urethane gel-filled channel]<Insert material>**.
 3. Filter Frame to Mounting Frame Seal Location: **[Upstream][Downstream]**.
 4. Style: **[Box][Gel track]<Insert style>**.
- 2.4 HEPA FILTER DIFFUSERS
- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Envirco]**
 4. **[Flanders Corporation]**
 5. **[Microzone Corporation]**
 6. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [AAF International]
2. [Camfil Farr Inc.]
3. [Envirco]
4. [Flanders Corporation]
5. [Microzone Corporation]
6. [Parker Hannifin Corporation; HVAC Filtration Division]
7. <Insert manufacturer's name>

- C. Source Limitations: Obtain from single source from single manufacturer.
- D. Description: Factory-fabricated, individually ducted, HEPA filter-holding ceiling modules.
- E. Standards:
1. Comply with IEST-RP-CC001.6.
 2. Comply with UL 586.
 3. Comply with IEST-RP-CC034.4.
- F. Media: Fibrous glass, constructed of continuous sheets with closely spaced pleats with separators.
1. Media to Frame Side Bond: Urethane or polyurethane sealant.
 2. Frame to Grid Bond: <Insert type of gasket>[gasket][Knife edge for gel-filled channel].
 3. Application: [Class 100,000 (ISO 8)][Class 10,000 (ISO 7)][Class 1,000 (ISO 6)][Class 100 (ISO 5)][Class 10 (ISO 4)]<Insert class> clean room.
- G. Casing:
1. Configuration: [Ducted][Plenum] inlet.
 2. Module Material: [Minimum 16-gauge (0.508-mm) extruded aluminum]<Insert gauge and material> with [mill]<Insert type> finish.
 3. Suspension: [Ceiling grid][Independent].
- H. Accessories:
1. [Fixed][Adjustable] diffusion damper.
 2. Diffusion-damper adjustment port.
 3. Filter test port.

2.5 HEPA FILTER FAN MODULES

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [AAF International]
 2. [Camfil Farr Inc.]
 3. [Envirco]
 4. [Microzone Corporation]
 5. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Envirco]**
 4. **[Microzone Corporation]**
 5. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain from single source from single manufacturer.
- D. Description: Factory-fabricated, HEPA filter ceiling module with fan.
- E. Standards:
1. Comply with IEST-RP-CC001.6.
 2. Comply with UL 586.
 3. Comply with IEST-RP-CC034.4.
- F. Media: Fibrous glass, constructed of continuous sheets with closely spaced pleats with separators.
1. Frame Material: **[Aluminum]<Insert material>**.
 2. Media to Frame Side Bond: Urethane or polyurethane sealant.
 3. Frame to Grid Bond: **<Insert type of gasket>[gasket][Knife edge for gel-filled channel]**.
 4. Application: **[Class 100,000 (ISO 8)][Class 10,000 (ISO 7)][Class 1,000 (ISO 6)][Class 100 (ISO 5)][Class 10 (ISO 4)]<Insert class>** clean room.
 5. Faceguard: **[Stainless steel]<Insert material>**.
- G. Casing:
1. Configuration: **[Ducted inlet][Plenum inlet][Plenum inlet with MERV 8 prefilter]**.
 2. Module Material: **[Minimum 16-gauge (0.508-mm) extruded aluminum]<Insert gauge and material>** with **[mill]<Insert type>** finish.
 3. Suspension: **[Ceiling grid][Independent]**.
- H. Accessories: Filter test port.
- I. Motor:
1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 2. Type: **[Permanent-split capacitor with SCR for speed adjustment][Electronically commutated motor]**.
 3. Fan-Motor Assembly Isolation: Rubber isolators.
 4. Enclosure: **<Insert type>**.
 5. Enclosure Materials: **<Insert type>**.
 6. Motor Bearings: **<Insert special requirements>**.
 7. Unusual Service Conditions:
 - a. Ambient Temperature: **<Insert number>deg F (deg C)**.
 - b. Altitude: **<Insert number> feet (m)** above sea level.
 - c. High humidity.
 - d. **<Insert conditions>**.
 8. Efficiency: Premium efficient.
 9. NEMA Design: **<Insert designation>**.
 10. Service Factor: **<Insert value>**.
 11. Motor Speed: **[Single speed][Multispeed][with variable-speed control]**.
 12. Electrical Characteristics:

- a. Horsepower: <Insert number> hp.
- b. Volts: [120][208][230][460]<Insert number> V.
- c. Phase: [Single][Three].
- d. Hertz: 60 Hz.
- e. Full-Load Amperes: <Insert number> A.
- f. Minimum Circuit Ampacity: <Insert number> A.
- g. Maximum Overcurrent Protection: <Insert number> A.

2.6 ULPA FILTERS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [AAF International]
 2. [Camfil Farr Inc.]
 3. [Flanders Corporation]
 4. [Parker Hannifin Corporation; HVAC Filtration Division]
 5. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [AAF International]
 2. [Camfil Farr Inc.]
 3. [Flanders Corporation]
 4. [Parker Hannifin Corporation; HVAC Filtration Division]
 5. <Insert manufacturer's name>
- C. Source Limitations: Obtain from single source from single manufacturer.
- D. Description: Factory-fabricated ULPA filters with holding casing.
- E. Standards:
1. Comply with IEST-RP-CC001.6.
 2. Comply with UL 586.
 3. Comply with IEST-RP-CC007.3.
 4. Comply with IEST-RP-CC034.4.
- F. Media: Fibrous material, constructed of continuous sheets with closely spaced pleats that are maintained under rated-airflow conditions.
1. Internal Separators: [None][Corrugated aluminum]<Insert type>.
 2. Media to Filter Frame Seal Material: [Polyurethane]<Insert material>.
 3. Faceguard Material: [Aluminum][Stainless steel]<Insert material>.
 4. Faceguard Location: [None][upstream][and][downstream].
- G. Filter-Media Frames:
1. Material: [Fire-retardant plywood][Aluminum][Fire-retardant particleboard][Galvanized steel][Non-fire-retardant particleboard]<Insert material>.
 2. Filter Frame to Mounting Frame Seal Material: [Neoprene][Silicone Gel][Urethane Gel]<Insert material>.

3. Filter Frame to Mounting Frame Seal Location: **[Upstream][Downstream]**.
4. Style: **[Box][Gel track]<Insert style>**.

2.7 95 PERCENT DOP FILTERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Flanders Corporation]**
 4. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Flanders Corporation]**
 4. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 5. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain filters from single source from single manufacturer.
- D. Description: Factory-fabricated, 95 percent DOP filters with holding casing.
- E. Media: Fibrous material, constructed of continuous sheets with closely spaced pleats that are maintained under rated-airflow conditions.
1. Internal Separators: **[None][Corrugated aluminum]<Insert type>**.
 2. Media to Filter Frame Seal Material: **[Polyurethane]<Insert material>**.
 3. Faceguard Material: **[Aluminum][Stainless steel]<Insert material>**.
 4. Faceguard Location: **[None][Upstream][Downstream]**.
- F. Filter-Media Frames:
1. Material: **[Fire-retardant plywood][Aluminum][Fire-retardant particleboard][Galvanized steel][Non-fire-retardant particleboard]<Insert material>**.
 2. Filter Frame to Mounting Frame Seal Material: **[Neoprene][Knife edge in silicone gel-filled channel][Knife edge in urethane gel-filled channel]**.
 3. Filter Frame to Mounting Frame Seal Location: **[Upstream][Downstream]**.
 4. Style: **[Box][Gel track]<Insert style>**.

2.8 HEPA/ULPA FILTER HOLDING FRAMES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Flanders Corporation]**

4. **[Parker Hannifin Corporation; HVAC Filtration Division]**
5. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[AAF International]**
2. **[Camfil Farr Inc.]**
3. **[Flanders Corporation]**
4. **[Parker Hannifin Corporation; HVAC Filtration Division]**
5. **<Insert manufacturer's name>**

C. Source Limitations: Obtain from single source from single manufacturer.

D. Description: Framing members with access for upstream (front) or downstream (back) filter servicing, cut to size and prepunched for assembly into modules, specifically designed for HEPA/ULPA/95 percent DOP filter banks.

E. Material: Minimum **14-gauge (1.9-mm)** **[stainless-][or][galvanized-]**steel framing members. Factory-prepunched holes and dimples for ease of filter alignment and assembly.

F. Prefilters: Incorporate a separate holding frame for prefilter, removable from front or back.

G. Gasketed Sealing: Factory-installed, positive-sealing device for each filter to ensure seal between gasketed filter elements to prevent bypass of unfiltered air. Filter latching mechanism to seat each filter firmly against holding frame surface.

H. Knife-Edge Sealing: Knife-edge to mate with **[HEPA][and][ULPA]** filter elements to prevent bypass of unfiltered air. Factory-installed, positive-locking mechanism for each filter to seat the knife edge into the gel during installation and to remove the filter from the knife edge during filter replacement.

2.9 SIDE-ACCESS HEPA/ULPA FILTER HOUSINGS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[AAF International]**
2. **[Camfil Farr Inc.]**
3. **[Flanders Corporation]**
4. **[Parker Hannifin Corporation; HVAC Filtration Division]**
5. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[AAF International]**
2. **[Camfil Farr Inc.]**
3. **[Flanders Corporation]**
4. **[Parker Hannifin Corporation; HVAC Filtration Division]**
5. **<Insert manufacturer's name>**

C. Source Limitations: Obtain from single source from single manufacturer.

- D. Description: Factory-assembled, side-access filter housings, specifically designed for HEPA/ULPA/95 percent DOP filter banks, with flanges to connect to duct or casing system.
- E. Factory Testing: Factory pressure test housing and sealed joints at **[6.0-inch wg (1500 Pa)]<Insert value>**. Document and submit to confirm maximum **<Insert percentage>** leakage.
- F. Materials: **[Galvanized steel]<Insert material>[double-wall casing with 1-inch (25-mm) insulation][double-wall casing with 2-inch (50-mm) insulation]**.
 - 1. Pressure taps and fittings.
 - 2. DOP test ports.
 - 3. Mounted magnehelic gauges.
- G. Prefilters: Integral tracks to accommodate **[2-inch- (50-mm-)][4-inch- (100-mm-)]<Insert dimension>** thick, disposable **[or washable]** filters.
- H. Access Doors: **[Hinged, with continuous][Continuous]** gaskets on perimeter and positive-locking devices. Arranged for filter access from **[one-side][both-sides]** access door.
- I. Gasketed Sealing: Factory-installed, positive-sealing device for each filter to ensure seal between gasketed filter elements to prevent bypass of unfiltered air. Filter latching mechanism to seat each filter firmly against side-access housing channel surface.
- J. Knife-Edge Sealing: Knife-edge to mate with **[HEPA][and][ULPA]** filter elements to prevent bypass of unfiltered air. Factory-installed, positive-locking mechanism for each filter to seat the knife edge into the gel during installation and to remove the filter from the knife edge during filter replacement.

2.10 SIDE-ACCESS HEPA/ULPA FILTER CONTAINMENT HOUSINGS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[AAF International]**
 - 2. **[Camfil Farr Inc.]**
 - 3. **[Flanders Corporation]**
 - 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[AAF International]**
 - 2. **[Camfil Farr Inc.]**
 - 3. **[Flanders Corporation]**
 - 4. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain from single source from single manufacturer.
- D. Description: Factory-assembled, side-access housings, with bag in/bag out feature to protect maintenance personnel from coming into direct contact with the interior of the housing and the contaminated filter media during required filter change out, with flanges to connect to duct or casing system.
- E. Standards: Test according to ASME AG-1.

F. Casing:

1. Material: Constructed of minimum **16-gauge- (1.5-mm-)** thick, **[galvanized steel][stainless steel][, double-wall casing with 2-inch (50-mm) fiberglass insulation,]** to hold filters. Side servicing through gasketed access doors on one side. Equip housings to be capable of connection to other housings. Equip housings with metal slide channel tracks and locking mechanisms to hold filters, and the following:
 - a. Pressure gauge tap and fitting.
 - b. DOP test ports.
 - c. Lifting lugs.
2. Casing Pressure: Casing constructed for up to **[positive/negative 6.0-inch wg (1500 Pa)][positive/negative 10-inch wg (2500 Pa)]<Insert casing pressure requirement>**.

G. Isolation Dampers:

1. Material: Stainless-steel body, blade, and flanges.
2. Round Damper Blade: **<Insert diameter>** damper, replaceable, solid silicone gasket sandwiched between stainless-steel plates, providing silicone gasket blade to knife edge seal.
 - a. Bubble-tight seal at minimum **10-inch wg (2490-Pa)** differential pressure to comply with ASME N509.

H. Prefilters: Integral tracks to accommodate [2-inch- (50-mm-)][4-inch- (100-mm-)] thick, disposable filters.**I. Access Doors: Continuous gaskets on perimeter and positive-locking devices. Provide ribbed bagging rim behind access door and PVC bags for bag-in, bag-out arrangement. Arrange so filter cartridges can be loaded from an access door for each tier and section of the following:**

1. Combination prefilter and HEPA filter.
2. HEPA filter.
3. Upstream and downstream test section.

J. Gasketed Sealing: Factory-installed, positive-sealing device for each filter to ensure seal between gasketed filter elements to prevent bypass of unfiltered air. Filter locking mechanism to seat each filter firmly against side-access housing channel surface.**K. Knife-Edge Sealing: Knife-edge to mate with [HEPA][and][ULPA] filter elements to prevent bypass of unfiltered air. Factory-installed, positive-locking mechanism for each filter to seat the knife edge into the gel during installation and to remove the filter from the knife edge during filter replacement.****L. Accessories:**

1. Filter change-out trays.
2. Document-storage pocket.
3. Filter removal rod.

2.11 HEPA, ULPA, AND 95 PERCENT DOP FILTER GAUGES**A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be**

incorporated into the Work include, but are not limited to, the following]:

1. [Ashcroft Inc]
 2. [Dwyer Instruments, Inc]
 3. [Orange Research]
 4. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Ashcroft Inc]
 2. [Dwyer Instruments, Inc]
 3. [Orange Research]
 4. <Insert manufacturer's name>
- C. Source Limitations: Obtain from single source from single manufacturer.
- D. Description: Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
1. Diameter: [4-1/2 inches (115 mm)][2-1/2 inches (75 mm)]<Insert dimension>.
 2. Material: [Stainless-steel]<Insert material> case and [die-cast aluminum][stainless-steel]<Insert material> body with [wetted material matching body material]<Insert wetted material>.
 3. Accuracy: [Plus/minus 2 percent of full scale]<Insert accuracy>.
 4. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: **0- to 3.0-inch wg (0 to 750 Pa)**.
 5. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: **0- to 4.0-inch wg (0 to 1000 Pa)**.
- E. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF FILTERS

- A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
- B. Install filters in position to prevent passage of unfiltered air.
- C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters that were used during construction and testing with new, clean filters.
- D. Coordinate filter installations with duct and air-handling unit installations.

3.3 INSTALLATION OF HEPA, ULPA, AND 95 PERCENT DOP FILTER GAUGES

- A. Install filter gauge for each filter bank.
- B. Install filter-gauge, static-pressure taps upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between pressure sensors and **[DDC system]<Insert system description>**.
- C. Connect control wiring between controlled devices.
- D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 - 1. HEPA and ULPA Filters: Pressurize housing to a minimum of **[6.0-inch wg (1500 Pa)]<Insert value>**, and test housing joints, door seals, and sealing edges of filter for air leaks according to pressure-decay method in ASME AG-1.
- E. Air filter will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.6 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

3.7 PROTECTION

- A. Protect installed products and accessories from damage during construction.



END OF SECTION 23 41 33 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 41 33 00	23 41 00 00	Particulate Air Filtration



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 42 00 00 - GAS-PHASE AIR FILTRATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Gas-phase panel filters.
2. Gas-phase, deep-V filters.
3. Gas-phase, V-cell filters.
4. Gas-phase, cylindrical-canister filters.
5. Gas-phase, rigid-cell box filters.
6. Front- or back-access filter frames.
7. Side-access filter housings.
8. Filter gauges.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for gas-phase filters.
2. Section 233400 "HVAC Fans" for customized fan and filter units.
3. Section 234133 "High-Efficiency Particulate Filtration" for high-efficiency particulate air (HEPA) filters used in combination with gas-phase filters.
4. Section 234300 "Electronic Air Cleaners" for electronic units combined with gas-phase filters as part of a system.

1.2 DEFINITIONS

- A. HIPS:** High impact polystyrene.

1.3 ACTION SUBMITTALS

- A. Product Data:** For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
- B. Sustainable Design Submittals:**
1. Product data showing compliance with ASHRAE 62.1.
- C. Shop Drawings:** For gas-phase air filters. Include plans, elevations, sections, details, and attachments to other work.
1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
 2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.



1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for gas-phase filters, accessories, and components from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Test Reports: For each gas-phase filter, for tests performed by **[manufacturer and witnessed by a qualified testing agency][a qualified testing agency]**.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of gas-phase filter and rack to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Provide **[one]<Insert number>** complete set(s) of filters for each filter or filter bank.
 - 2. Provide **[one]<Insert number>** complete 100 percent refill supply for each filter requiring loose-fill media.
 - 3. Provide **[one]<Insert number>** container(s) of red oil for inclined manometer filter gage.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Filters shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]**."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

- B. ASHRAE 62.1 Compliance: Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."
- C. Comply with NFPA 90A and NFPA 90B.

2.2 GAS-PHASE PANEL FILTERS

- A. Description: Factory-fabricated panel or pleated adsorbent media filter.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[AAF International]**
 - 2. **[Camfil Farr Inc.]**
 - 3. **[Flanders Corporation]**
 - 4. **[Koch Filter Corporation]**
 - 5. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 - 6. **[Purafil, Inc.]**
 - 7. **[Tri-Dim Filter Corporation]**
 - 8. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[AAF International]**
 - 2. **[Camfil Farr Inc.]**
 - 3. **[Flanders Corporation]**
 - 4. **[Koch Filter Corporation]**
 - 5. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 - 6. **[Purafil, Inc.]**
 - 7. **[Tri-Dim Filter Corporation]**
 - 8. **<Insert manufacturer's name>**
- D. Filter Unit Class: UL 900, **[Class 2]<Insert class>**.
- E. Capacities and Characteristics:
 - 1. Drawing Tag No.: **<Insert number>**.
 - 2. Face Size: **[24 by 24 inches (600 by 600 mm)][20 by 24 inches (500 by 600 mm)][24 by 12 inches (600 by 300 mm)]<Insert dimensions>** nominal.
 - 3. Depth: **[1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)]<Insert dimension>** nominal.
 - 4. System Airflow: **<Insert cfm (L/s)>**.
 - 5. Maximum or Rated Face Velocity: **[500 fpm (2.5 m/s)]<Insert value>**.
 - 6. No. of Filters, Wide by High: **<Insert number wide by number high>**.
 - 7. Service Access Location (Front, Back, Side): **<Insert access location>**.
 - 8. Initial Resistance: **[0.50-inch wg (125 Pa)]<Insert value>**.
 - 9. Final Resistance: **[1.0-inch wg (250 Pa)]<Insert value>**.
- F. Media:
 - 1. Flat-panel or pleated, multilayer filter with an inlet layer of nonwoven polyester fibers, bonded or supported by a grid, to a layer of **[activated carbon]<Insert adsorbent media type>**
 - 2. Housed in a **[beverage board]<Insert material>** frame.
 - 3. Minimum CTC activity level of **[60]<Insert number>** percent.

- G. MERV Rating: Minimum **[MERV 6][MERV 8]<Insert value>**, according to ASHRAE 52.2.
- H. Maximum Continuous Operating Temperature: **[150 deg F (65 deg C)]<Insert temperature>**.
- I. Pre-installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption prior to installation.

2.3 GAS-PHASE, DEEP-V FILTERS

- A. Description: Factory-fabricated modules with adsorbent media trays or self-supporting bonded media panels in deep-V arrangement with disposable **[prefilter][and][final filter]**.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[AAF International]**
 - 2. **[Camfil Farr Inc.]**
 - 3. **[Flanders Corporation]**
 - 4. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 - 5. **[Tri-Dim Filter Corporation]**
 - 6. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[AAF International]**
 - 2. **[Camfil Farr Inc.]**
 - 3. **[Flanders Corporation]**
 - 4. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 - 5. **[Tri-Dim Filter Corporation]**
 - 6. **<Insert manufacturer's name>**
- D. Filter Unit Class: UL 900, **[Class 2]<Insert class>**.
- E. Capacities and Characteristics:
 - 1. Drawing Tag No.: **<Insert number>**.
 - 2. Face Size: **[24 by 24 inches (600 by 600 mm)][20 by 24 inches (500 by 600 mm)][24 by 12 inches (600 by 300 mm)][12 by 24 inches (300 mm by 600 mm)]<Insert dimensions>** nominal.
 - 3. Depth: **<Insert dimension>** nominal.
 - 4. System Airflow: **<Insert cfm (L/s)>**.
 - 5. Maximum or Rated Face Velocity: **[500 fpm (2.5 m/s)]<Insert value>**.
 - 6. No. of Tray/Cassette/Panel Modules, Wide by High: **<Insert number wide by number high>**.
 - 7. Service Access Location (Front, Back, or Side): **<Insert access location>**.
 - 8. Resistance: **[0.50-inch wg (125 Pa)]<Insert value>**.
 - 9. Recommended Change-out Interval Frequency: **[1 year]<Insert change-out interval frequency>**.
- F. Module Housing:
 - 1. Frame: **[Galvanized or powder-coated steel][Stainless steel][HIPS][Galvanized steel, powder-coated steel, stainless steel, or HIPS]** to hold adsorbent media-filled trays or panels.

2. Access: **[Front access][or][Side access through gasketed access doors on both sides]** and able to connect to other housings.
 3. Equip housings with **[metal slide channel tracks to hold adsorbent media trays or self-supporting panels][or][interlocking modular cassettes to hold adsorbent media][and][particulate prefilter][final filter]**.
 4. Finish: **[unfinished HIPS material][or][Steel with treatment(s) as indicated in "Frame" Subparagraph above], [factory][primed][primed and painted], [outside][inside and outside][inside]**.
 5. Pressure tap and fitting.
- G. Media-Holding Panels:
1. **[Refillable][Disposable][or][Incinerable]** adsorbent media trays or self-supporting panels.
- H. Activated Carbon Media: **<Insert lb (kg)> per 1000 cfm (470 L/s)** of **[loose-fill][loose-fill or bonded-panel][bonded-panel]** coconut-shell activated carbon.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>, [90]<Insert number>** percent minimum.
 5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.
- I. Potassium-Permanganate-Impregnated Media: **<Insert lb (kg)> per 1000 cfm (470 L/s)** of **[loose-fill][loose-fill or bonded-panel][bonded-panel]** activated alumina or zeolite impregnated with potassium permanganate.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>, [90]<Insert number>** percent minimum.
 5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.
- J. Caustic Sodium-Hydroxide-Impregnated Activated Carbon Media: **<Insert lb (kg)> per 1000 cfm (470 L/s)** of **[loose-fill][loose-fill or bonded-panel][bonded-briquette]** caustic sodium-hydroxide-impregnated activated carbon.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>, [90]<Insert number>** percent minimum.
 5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.
- K. Blended Activated Carbon and Potassium-Permanganate-Impregnated Media: **<Insert lb (kg)> per 1000 cfm (470 L/s)** of **[loose-fill][loose-fill or bonded-panel][bonded-panel]**, 50/50 blended activated carbon and alumina or zeolite impregnated with potassium permanganate.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.

3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>**, **[90]<Insert number>** percent minimum.
 5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.
- L. Phosphoric-Acid-Impregnated Activated Carbon Media: **<Insert lb (kg)>** per **1000 cfm (470 L/s)** of **[loose-fill][loose-fill or bonded-panel][bonded-panel]** activated carbon impregnated with phosphoric acid.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>**, **[90]<Insert number>** percent minimum.
 5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.
- M. Prefilter: Comply with requirements in Section 234100 "Particulate Air Filtration" for **[flat][pleated][ring]** panel. Size and airflow capacity shall match those of gas-phase filters.
1. Depth: **[1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)]<Insert dimension>**.
 2. Maximum or Rated Face Velocity: **[500 fpm (2.5 m/s)]<Insert value>**.
 3. Initial Resistance: **[0.25-inch wg (62.3 Pa)][0.35-inch wg (87.2 Pa)][0.45-inch wg (112.1 Pa)][0.60-inch wg (150 Pa)]<Insert value>** at **[350 fpm (1.8 m/s)][500 fpm (2.5 m/s)]<Insert value>**.
 4. Recommended Final Resistance: **<Insert inches wg (Pa)>**.
 5. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating: **[MERV 1][MERV 2][MERV 3][MERV 4]<Insert value>**, according to ASHRAE 52.2.
 6. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 13]<Insert value>**, according to ASHRAE 52.2.
- N. Final Filter: Comply with requirements in Section 234100 "Particulate Air Filtration" for **[supported bag][unsupported bag][rigid-cell box][V-bank cell][self-supported pocket]** filter. Size and airflow capacity shall match those of gas-phase filters.
1. Depth: **[12 inches (300 mm)][18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>**.
 2. Maximum or Rated Face Velocity: **[500 fpm (2.5 m/s)]<Insert value>**.
 3. Initial Resistance: **[1-inch wg (250 Pa)][2-inch wg (500 Pa)]<Insert value>** at **500 fpm (2.5 m/s)**.
 4. Recommended Final Resistance: **<Insert inches wg (Pa)>**.
 5. Filter Unit Class: UL 900, **[Class 1][Class 2]**.
 6. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 13]<Insert value>**, according to ASHRAE 52.2.
- O. Pre-installation Protection: Package each gas-phase filter in sealed polyethylene bag to prevent unintentional adsorption prior to installation.

2.4 GAS-PHASE, V-CELL FILTERS

- A. Description: Factory-fabricated, dry, V-shaped cartridges containing loose-fill adsorbent media with

holding frames.

- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Filtration Group]**
 4. **[Flanders Corporation]**
 5. **[Koch Filter Corporation]**
 6. **[Purafil, Inc.]**
 7. **[Tri-Dim Filter Corporation]**
 8. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Filtration Group]**
 4. **[Flanders Corporation]**
 5. **[Koch Filter Corporation]**
 6. **[Purafil, Inc.]**
 7. **[Tri-Dim Filter Corporation]**
 8. **<Insert manufacturer's name>**
- D. Capacities and Characteristics:
1. Drawing Tag No.: **<Insert number>**.
 2. Face Size: **[24 by 24 inches (600 by 600 mm)][20 by 24 inches (500 by 600 mm)][24 by 12 inches (600 by 300 mm)]<Insert dimensions>**nominal.
 3. Depth: **[12 inches (300 mm)]<Insert dimension>** nominal.
 4. System Airflow: **<Insert cfm (L/s)>**.
 5. Maximum or Rated Face Velocity: **[500 fpm (2.5 m/s)]<Insert value>**.
 6. No. of Filters, Wide by High: **<Insert number wide by number high>**.
 7. Service Access Location (Front, Back, or Side): **<Insert access location>**.
 8. Resistance: **[0.50-inch wg (125 Pa)]<Insert value>**.
 9. Recommended Change-out Interval Frequency: **[1 year]<Insert change-out interval frequency>**.
- E. Cartridges: V-cell configuration; plastic enclosure caps; galvanized-steel, HIPS, or ABS frame with vertical galvanized-steel, HIPS, or ABS channel supports. Integral, **[1-inch (25-mm)]<Insert media bed thickness>** thick panels constructed of honeycombed paper and nylon mesh or mini-pleats on each side of adsorbent media.
- F. Coconut-Shell Activated Carbon Media: **<Insert lb (kg)>** of activated carbon per **1000 cfm (470 L/s)** of airflow.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>**, **[90]<Insert number>** percent minimum.
 5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.

- G. Activated Alumina or Zeolite Impregnated with Potassium-Permanganate Media: **<Insert lb (kg)>** of adsorbent per **500 cfm (236 L/s)** of airflow.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>**, **[90]<Insert number>** percent minimum.
 5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.
- H. Caustic Sodium-Hydroxide-Impregnated Carbon Media: **<Insert lb (kg)>** of adsorbent per **500 cfm (236 L/s)** of airflow.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>**, **[90]<Insert number>** percent minimum.
 5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.
- I. 50/50 Blended Carbon and Alumina or Zeolite Impregnated with Potassium-Permanganate Media: **<Insert lb (kg)>** of adsorbent per **500 cfm (236 L/s)** of airflow.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>**, **[90]<Insert number>** percent minimum.
 5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.
- J. Activated Carbon Impregnated with Phosphoric Acid Media: **<Insert lb (kg)>** of adsorbent per **500 cfm (236 L/s)** of airflow.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>**, **[90]<Insert number>** percent minimum.
 5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.
- K. Media: **<Insert lb (kg)>** per **1000 cfm (470 L/s)** of **<Insert type of media and adsorbent>**.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>**, **[90]<Insert number>** percent minimum.
 5. Hardness Factor: **<Insert number>**, when tested according to ASTM D3802.
 6. Prefilter: Comply with requirements in Section 234100 "Particulate Air Filtration" for **[flat][pleated][ring]** panel. Size and airflow capacity shall match those of gas-phase filters.

- a. Depth: [1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)]<Insert dimension>.
- b. Maximum or Rated Face Velocity: [500 fpm (2.5 m/s)]<Insert value>.
- c. Initial Resistance: [0.25-inch wg (62.3 Pa)][0.35-inch wg (87.2 Pa)][0.45-inch wg (112.1 Pa)][0.60-inch wg (150 Pa)]<Insert value> at [350 fpm (1.8 m/s)][500 fpm (2.5 m/s)]<Insert value>.
- d. Recommended Final Resistance: <Insert inches wg (Pa)>.
- e. Filter Unit Class: UL 900, [Class 2]<Insert class>.
- f. Minimum Efficiency Reporting Value and Average Arrestance:
 - 1) MERV Rating: [MERV 1][MERV 2][MERV 3][MERV 4], according to ASHRAE 52.2.
- g. Minimum Efficiency Reporting Value:
 - 1) MERV Rating: [MERV 6][MERV 13]<Insert value>, according to ASHRAE 52.2.
7. Final Filter: Comply with requirements in Section 234100 "Particulate Air Filtration" for [supported bag][unsupported bag][rigid-cell box][V-bank cell][self-supported pocket] filter. Size and airflow capacity shall match those of gas-phase filters.
 - a. Depth: [12 inches (300 mm)][18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>.
 - b. Maximum or Rated Face Velocity: [500 fpm (2.5 m/s)]<Insert value>.
 - c. Initial Resistance: [1-inch wg (250 Pa)][2-inch wg (500 Pa)]<Insert value> at 500 fpm (2.5 m/s).
 - d. Recommended Final Resistance: <Insert inches wg (Pa)>.
 - e. Filter Unit Class: UL 900, [Class 1][Class 2].
 - f. Minimum Efficiency Reporting Value:
 - 1) MERV Rating: [MERV 13]<Insert value>, according to ASHRAE 52.2.
- L. Pre-installation Protection: Package each filter in a sealed polyethylene bag to prevent unintentional adsorption prior to installation.

2.5 GAS-PHASE, CYLINDRICAL-CANISTER FILTERS

- A. Description: Factory-fabricated, dry, cylindrical canisters containing loose-fill adsorbent with holding frames.
- B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [Camfil Farr Inc.]
 2. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 1. [Camfil Farr Inc.]
 2. <Insert manufacturer's name>
- D. Filter Unit Class: UL 900, [Class 2]<Insert class>.
- E. Capacities and Characteristics:

1. Drawing Tag No.: **<Insert number>**.
 2. Module Face Size: **[24 by 24 inches (600 by 600 mm)]****[24 by 12 inches (600 by 300 mm)]****<Insert dimensions>** nominal.
 3. Cylinder Diameter: **[6 inches (150 mm)]****<Insert dimension>** nominal.
 4. Cylinder Length: **[18 inches (450 mm)]****[24 inches (600 mm)]****<Insert dimension>** nominal.
 5. System Airflow: **[Insert cfm (L/s)]**.
 6. Maximum or Rated Face Velocity: **[500 fpm (2.5 m/s)]****<Insert value>**.
 7. No. of Modules, Wide by High: **<Insert number wide by number high>**.
 8. Service Access Location (Front, Back, Side): **<Insert access location>**.
 9. Resistance: **[0.50-inch wg (125 Pa)]****<Insert value>**.
 10. Recommended Change-out Interval Frequency: **[1 year]****<Insert change-out frequency>**.
- F. Cylinders: **[Disposable plastic, 105 deg F (41 deg C) maximum continuous operating temperature)]****[Factory-refillable stainless steel, 140 deg F (60 deg C) maximum continuous operating temperature]**.
- G. Media: **1-inch- (25-mm-) thick adsorbent bed, 1.5 lb (0.68 kg) <Insert lb. (kg)> of adsorbent per 6-inch- (150-mm-) diameter cylinder of [activated carbon][activated alumina or zeolite impregnated with potassium permanganate][caustic sodium-hydroxide-impregnated carbon][50/50 blended carbon and alumina or zeolite impregnated with potassium permanganate][activated carbon impregnated with phosphoric acid]****<Insert media type>** per canister.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]****<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
 4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]****<Insert mesh size>**, **[90]****<Insert number>** percent minimum.
 5. Hardness Factor: **<Insert number>**, when tested according to ASTM D3802.
- H. Cylinder-Canister Filter-Mounting Frames: **[Disposable plastic]****[Factory-refillable stainless steel]****<Insert material>** with adsorbent cylinder air paths and mounting perforations; designed for connecting together into built-up filter banks. Secure cylinders to mounting frame with bayonet mounts and gasket seals.
- I. Cylindrical-Canister Filter Side Access Housing Modules: **[16-gage aluminized steel]****<Insert material>**, gasketed dual access doors, **[anodized-aluminum]****<Insert material>** filter tracks for cylindrical-canister filters, **[with separate track for]****[2-inch (50-mm)]****<Insert prefilter thickness>** prefilters; individual modules designed for connecting together into built-up filter banks.
- J. Prefilter: Comply with requirements in Section 234100 "Particulate Air Filtration" for **[flat]****[pleated]****[ring]** panel. Size and airflow capacity shall match those of gas-phase filters.
1. Depth: **[2 inches (50 mm)]****<Insert dimension>**.
 2. Maximum or Rated Face Velocity: **[500 fpm (2.5 m/s)]****<Insert value>**.
 3. Initial Resistance: **[0.25-inch wg (62.3 Pa)]****<Insert value>** at **[500 fpm (2.5 m/s)]****<Insert value>**.
 4. Recommended Final Resistance: **<Insert inches wg (Pa)>**.
 5. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating: **[MERV 4]****<Insert value>**, according to ASHRAE 52.2.
 6. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6]****[MERV 13]****<Insert value>**, according to ASHRAE 52.2.

- K. Pre-installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption prior to installation.

2.6 GAS-PHASE, RIGID-CELL BOX FILTERS

- A. Description: Factory-fabricated, adsorbent media bonded to nonwoven deep pleats with plastic pleat spacers, contained in a rigid-cell box.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Filtration Group]**
 4. **[Flanders Corporation]**
 5. **[Koch Filter Corporation]**
 6. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 7. **[Purafil, Inc.]**
 8. **[Tri-Dim Filter Corporation]**
 9. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Filtration Group]**
 4. **[Flanders Corporation]**
 5. **[Koch Filter Corporation]**
 6. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 7. **[Purafil, Inc.]**
 8. **[Tri-Dim Filter Corporation]**
 9. **<Insert manufacturer's name>**
- D. Filter Unit Class: UL 900, **[Class 1][Class 2]**.
- E. Capacities and Characteristics:
1. Drawing Tag No.: **<Insert number>**.
 2. Face Size: **[24 by 24 inches (600 by 600 mm)][24 by 12 inches (600 by 300 mm)]<Insert dimensions>** nominal.
 3. Depth: **[12 inches (300 mm)]<Insert dimension>** nominal.
 4. System Airflow: **<Insert cfm (L/s)>**.
 5. Maximum or Rated Face Velocity: **[500 fpm (2.5 m/s)]<Insert value>**.
 6. Initial Resistance: **[0.50-inch wg (140 Pa)]<Insert value>**.
 7. Recommended Final Resistance: **[1.5 in wg (370 Pa)]<Insert inches wg (Pa)>**.
 8. Minimum Toluene Removal Efficiency: **[90]<Insert value>** percent.
- F. Activated Carbon Media: **<Insert lb (kg)>** of activated carbon per **1000 cfm (470 L/s)** of airflow.
1. Ash Content: **<Insert number range>** percent.
 2. Percentage of CTC Activity: **[60]<Insert number>** percent minimum, when tested according to ASTM D3467.
 3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m) value>**.



4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>, [90]<Insert number>** percent minimum.
5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.

G. 50/50 Blended Carbon and Alumina or Zeolite Impregnated with Potassium-Permanganate Media: **<Insert lb (kg)>** of adsorbent per **1000 cfm (470 L/s)** of airflow.

1. Ash Content: **<Insert number range>** percent.
2. Percentage of CTC Activity: **[60]<Insert number range>** percent minimum, when tested according to ASTM D3467.
3. Bulk Density: **<Insert lb/cu. ft. (kg/cu. m)>**.
4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>, [90]<Insert number>** percent minimum.
5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.

H. Media: **<Insert lb (kg)>** per **1000 cfm (470 L/s)** of **<Insert type of media and adsorbent>**.

1. Ash Content: **<Insert number range>** percent.
2. Percentage of CTC Activity: **[60]<Insert number range>** percent minimum, when tested according to ASTM D3467.
3. Bulk Density: **<Insert lb/cu. ft (kg/cu. m)>**.
4. Mesh Size: **[4 x 6 U.S. standard mesh (4.75 x 3.35 mm)]<Insert mesh size>, [90]<Insert number>** percent minimum.
5. Hardness Factor: **[95]<Insert number>**, when tested according to ASTM D3802.

I. Filter-Media Frame: **[Galvanized steel]<Insert material>**.

J. Pre-installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption prior to installation.

2.7 FRONT- OR BACK-ACCESS FILTER FRAMES

A. Framing System: **[Galvanized-steel][Aluminum]** framing members with access for upstream (front) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[AAF International]**
2. **[Flanders Corporation]**
3. **[Koch Filter Corporation]**
4. **[Parker Hannifin Corporation; HVAC Filtration Division]**
5. **[Purafil, Inc.]**
6. **<Insert manufacturer's name>**

C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[AAF International]**
2. **[Flanders Corporation]**
3. **[Koch Filter Corporation]**
4. **[Parker Hannifin Corporation; HVAC Filtration Division]**

5. [Purafil, Inc.]
6. <Insert manufacturer's name>

- D. Prefilters: Incorporate a separate track[**with spring clips**], removable from front [or][back].
- E. Sealing: Factory-installed, positive-sealing device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air.

2.8 SIDE-ACCESS FILTER HOUSINGS

- A. Description: Factory-assembled, side-access housings constructed of **[galvanized steel][aluminum]<Insert material>** with flanges to connect to duct or casing system.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Flanders Corporation]**
 4. **[Koch Filter Corporation]**
 5. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 6. **[Purafil, Inc.]**
 7. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[AAF International]**
 2. **[Camfil Farr Inc.]**
 3. **[Flanders Corporation]**
 4. **[Koch Filter Corporation]**
 5. **[Parker Hannifin Corporation; HVAC Filtration Division]**
 6. **[Purafil, Inc.]**
 7. **<Insert manufacturer's name>**
- D. Prefilters: Integral tracks to accommodate **[2-inch- (50-mm-)]<Insert thickness>** thick, disposable[**or washable**] filters.
- E. Access Doors: **[Hinged with continuous][Continuous]** gaskets on perimeter and with positive-locking devices. Arrange so filter cartridges can be loaded from either access door.
- F. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.9 FILTER GAUGES

- A. Diaphragm type, with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:



1. [Dwyer Instruments, Inc]
 2. [Parker Hannifin Corporation; HVAC Filtration Division]
 3. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Dwyer Instruments, Inc]
 2. [Parker Hannifin Corporation; HVAC Filtration Division]
 3. <Insert manufacturer's name>
- D. Diameter: [4-1/2 inches (115 mm)][2 inches (50 mm)].
- E. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: **0- to 0.5-inch wg (0 to 125 Pa)**.
- F. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: **0- to 1.0-inch wg (0 to 250 Pa)**.
- G. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: **0- to 2.0-inch wg (0 to 500 Pa)**.
- H. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: **0- to 3.0-inch wg (0 to 750 Pa)**.
- I. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: **0- to 4.0-inch wg (0 to 1000 Pa)**.
- J. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale, logarithmic-curve tube gage with integral leveling gage; graduated to read from **0- to 3.0-inch wg (0 to 750 Pa)** and accurate within 3 percent of full-scale range.
- K. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF FILTERS

- A. Position each filter unit with required clearance for service and maintenance. Anchor filter-mounting frames to substrate.
- B. Install filters in position to prevent passage of unfiltered air.
- C. Do not operate fan system until particulate filters (temporary or permanent) are in place. Replace

temporary filters used during construction and testing with new, clean filters.

- D. Do not install gas-phase filters until fan system is clean and there is no risk of construction debris loading the filter.
- E. Install filter-gauge, static-pressure taps upstream and downstream from each filter bank. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.
- F. Coordinate filter installations with duct and air-handling-unit installations.
- G. Install all manufacturer-provided accessories in accordance with manufacturer's written installation instructions.

3.3 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between pressure sensors and **[DDC control system]<Insert system description>**.
- C. Connect control wiring between controlled devices.
- D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Test for leakage of unfiltered air while system is operating.
- D. Air filters will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.5 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new particulate filter media.

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



3.6 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain filters.

END OF SECTION 23 42 00 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 42 13 00	23 41 00 00	Particulate Air Filtration
23 42 13 00	23 42 00 00	Gas-Phase Air Filtration



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 43 00 00 - ELECTRONIC AIR CLEANERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electronic air cleaners.
2. Fan section.
3. Cabinet.
4. Filter gauges.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for particulate air filters.
2. Section 233416 "Centrifugal HVAC Fans" for customized fan and filter units.
3. Section 234133 "High-Efficiency Particulate Air Filtration" for high-efficiency particulate air filters used in combination with particulate air filters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For each electronic air cleaner.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Show filter assembly, dimensions, materials, and methods of assembly of components.
3. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for filters, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Test Reports: For each filter, for tests performed by **[manufacturer and witnessed by a**



qualified testing agency][a qualified testing agency].

- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of filter and housing to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide [one]<Insert number> complete set(s) of prefilters for each filter bank.
2. Provide detergent for [one][two]<Insert number> refill(s).
3. Provide [one]<Insert number> container(s) of red oil for inclined manometer filter gauge.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Filters shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7]<Insert requirement>.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[and the unit will be fully operational after the seismic event]."
2. Component Importance Factor: [1.5][1.0].
3. <Insert requirements for Component Amplification Factor and Component Response Modification Factor>.

- B. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

- C. Comply with AHRI 850.

- D. Comply with [NFPA 90A][NFPA 90B].

- E. Comply with UL 867.

- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a

qualified testing agency, and marked for intended location and application.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Drawing Tag. No.: **<Insert number>**.
- B. Face Size: **[48 by 24 inches (1152 by 600 mm)]<Insert dimensions>** nominal.
- C. Number of Cleaner Units: **<Insert number>**.
- D. Unit Depth: **<Insert dimensions>** nominal.
- E. Frame Access Location: **[Front][back][or][side]**.
- F. System Airflow: **<Insert number> cfm (L/s)**.
- G. Maximum or Rated Face Velocity: **[500 fpm (2.5 m/s)]<Insert number>**.
- H. Power Pack:
 - 1. Volts: **[120][208][230][460]<Insert number> V**.
 - 2. Phase: **[Single][Three]**.
 - 3. Hertz: 60 Hz.
 - 4. Full-Load Amperes: **<Insert number> A**.
 - 5. Minimum Circuit Ampacity: **<Insert number> A**.
- I. Maximum Overcurrent Protection Device: **<Insert number> A**.
- J. Efficiency: **<Insert number>** percent on particles **<Insert number>** microns and larger at **500 fpm (2.5 m/s)**.
- K. Initial Resistance: **[0.25-inch wg (63 Pa)]<Insert number>**.
- L. Prefilter Type: Integral tracks to accommodate **[1-inch- (25-mm-)][2-inch- (50-mm-)][4-inch- (100-mm-)]** thick, disposable **[or washable]** filters.
 - 1. Prefilter Face Size: **<Insert width by height>**.
 - 2. Number of Prefilters, Wide by High: **<Insert number wide by number high>**.
 - 3. Minimum Efficiency Reporting Value (MERV) and Average Arrestance: MERV **[4]<Insert number>**, with "Composite Average Particle Size Efficiency and Arrestance, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
 - 4. Minimum Efficiency Reporting Value: MERV **[6]<Insert number>**, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
- M. Final Filter Type: Integral tracks to accommodate **[12-inch (300-mm)][18-inch (450-mm)][24-inch (600-mm)]<Insert dimension>** disposable filters.
 - 1. Final-Filter Face Size: **<Insert width by height>**.
 - 2. Number of Final Filters, Wide by High: **<Insert number wide by number high>**.
 - 3. Minimum Efficiency Reporting Value: MERV **[6]<Insert number>**, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
- N. Fan Motor Electrical Characteristics:

1. Horsepower: <Insert number> hp.
2. Volts: [120][208][230][460]<Insert number> V.
3. Phase: [Single][3].
4. Hertz: 60 Hz.
5. Full-Load Amperes: <Insert number> A.
6. Minimum Circuit Ampacity: <Insert number> A.
7. Maximum Overcurrent Protection Device: <Insert number> A.

O. Cleaning System: [Manual][or][automatic].

P. Reservoir Tank: [30 gal. (114 L)][50 gal. (190 L)].

Q. Connections:

1. Water Supply: <Insert number> NPS (DN).
2. Drain: <Insert number> NPS (DN).

2.3 ELECTRONIC AIR CLEANERS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Air Quality Engineering, Inc.]
2. [CosaTron, a division of CRS Industries, Inc.]
3. [Trion, Inc.]
4. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Air Quality Engineering, Inc.]
2. [CosaTron, a division of CRS Industries, Inc.]
3. [Trion, Inc.]
4. <Insert manufacturer's name>

C. Description: Factory-fabricated, electronic air cleaner operating by electrostatic precipitation principles.

D. Prefilter Media: [Four][Six] alternate layers of [galvanized-steel][aluminum][stainless-steel], flat and herringbone-crimp screen.

E. Prefilter: Comply with requirements in Section 234100 "Particulate Air Filtration" for [flat][pleated][ring] panel. Size and airflow capacity shall match those of electronic air cleaners.

1. Depth: [1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)]<Insert dimension>.
2. Comply with UL 900.

F. Final Filter: Comply with requirements in Section 234100 "Particulate Air Filtration" for [supported bag][unsupported bag][rigid-cell box][V-bank cell][self-supported pocket]. Size and airflow capacity shall match those of electronic air cleaners.

1. Depth: [12 inches (300 mm)][18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>.
2. Comply with UL 900.

- G. Collection Cells: Aluminum, independently supported and nested.
 - 1. Ionizing Section: Alternately spaced grounded struts and charged ionizing wires.
 - 2. Collecting Section: Alternately grounded and charged plates, with insulators located out of airstream.
- H. Power Pack: Self-contained, prewired rectifying unit to convert power, as **[scheduled on Drawings][identified in "Capacities and Characteristics" Article]**, to approximately 12,000 V dc for ionizer and 6000 V dc for collector; include overload protection, on-off switch, pilot light showing operating status, and access door interlock. Alternatively provide high-voltage and high-frequency-grid excitation technology power pack and system.
- I. Safety Accessories: Manual-reset safety switches and warning lights for filter plenum access doors, signal lights and safety switching upstream and downstream from unit within duct, and enameled high-voltage warning signs.
- J. Collection Section Cleaning System:
 - 1. Detergent Reservoir Tank: **[30 gal. (110 L)][55 gal. (200 L)]<Insert capacity>** with pump, motor, solenoid valve, level sensor, backflow preventer, wye-strainer, and ball valve.
 - 2. Detergent.
 - 3. Dispensing System: Motor-driven oscillating copper manifolds with brass spray nozzles on each side of the collector.
- K. Controls: Programmable logic controller in remotely mounted, NEMA 250, Type 12 enclosure; with integral time clock and manual override.
 - 1. Contacts for enable-disable control by building automation system.
- L. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with ASHRAE 62.1.

2.4 FAN SECTION

- A. Fan: **[Forward curved, belt driven]<Insert fan and drive type>**.
- B. Motor:
 - 1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2. Type: **[Permanent-split capacitor with SCR for speed adjustment][Electronically commutated motor]<Insert type>**.
 - 3. Fan-Motor Assembly Isolation: Rubber isolators.
 - 4. Enclosure: Totally enclosed, fan cooled, and **[explosion proof][dust-ignition proof]<Insert type>**.
 - 5. Enclosure Materials: **[Cast iron][Cast aluminum][Rolled steel]<Insert type>**.
 - 6. Motor Bearings: Sealed ball, **<Insert special requirements>**.
 - 7. Unusual Service Conditions:
 - a. Ambient Temperature: **<Insert number> deg F (deg C)**.
 - b. Altitude: **<Insert number> feet (m)** above sea level.
 - c. High humidity.
 - d. **<Insert conditions>**.
 - 8. Efficiency: Premium efficient.
 - 9. NEMA Design: **<Insert designation>**.



10. Service Factor: **<Insert value>**.
11. Motor Speed: **[Single speed][Multispeed][Infinitely adjustable with electronic controls]**.

2.5 CABINET

- A. Description: Minimum **<Insert number> gauge (mm)** galvanized steel with **<Insert type>** finish for suspended, wall, frame, or duct mounting.

2.6 FILTER GAUGES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Dwyer Instruments, Inc]**
2. **[Parker Hannifin Corporation; HVAC Filtration Division]**
3. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Dwyer Instruments, Inc]**
2. **[Parker Hannifin Corporation; HVAC Filtration Division]**
3. **<Insert manufacturer's name>**

- C. Description: Diaphragm type, with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Diameter: **[4-1/2 inches (115 mm)][2 inches (50 mm)]**.
2. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: **0- to 0.5-inch wg (0 to 125 Pa)**.
3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: **0- to 1.0-inch wg (0 to 250 Pa)**.
4. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: **0- to 2.0-inch wg (0 to 500 Pa)**.

- D. Manometer-Type Filter Gauge: Molded plastic, with epoxy-coated aluminum scale, logarithmic-curve tube gauge, with integral leveling indicator, graduated to read from **0- to 3.0-inch wg (0 to 750 Pa)**, and accurate within 3 percent of full-scale range.

- E. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine electronic air cleaners and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Position each electronic air cleaner unit with clearance for normal service and maintenance. Anchor electronic air cleaners to substrate.
- B. Do not operate fan system until electronic air cleaners and associated prefilters and final filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- C. Operate electronic air cleaners for 24 hours as part of startup before units are put into operation.
- D. Install filter-gauge, static-pressure taps upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.
- E. Install and connect water-supply and drainage piping.
- F. Coordinate electronic air cleaner and associated prefilter and final filter installations with duct and air-handling-unit installations.

3.3 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between pressure sensors and **[DDC system]<Insert system description>**.
- C. Connect control wiring between controlled devices.
- D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections: Test for leakage of unfiltered air while system is operating.
- E. Electronic air cleaner and associated filters will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



3.5 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean electronic air filter housings and install new prefilter and final-filter media.

3.6 PROTECTION

- A. Protect installed products and accessories from damage during construction.

END OF SECTION 23 43 00 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 43 23 00	23 43 00 00	Electronic Air Cleaners
23 43 33 00	23 43 00 00	Electronic Air Cleaners



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 51 13 00 - DRAFT CONTROL FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Draft inducer fans.
2. Venturi-draft inducer fans.
3. Mechanical-draft vent fans.
4. Vent exhaust fans.
5. Combustion-air fans.

B. Related Requirements:

1. Section 235113.16 "Vent Dampers" for barometric dampers and vent dampers.
2. Section 235116 "Fabricated Breechings and Accessories" for listed, refractory-lined metal breechings and field-fabricated metal breechings.
3. Section 235123 "Gas Vents" for Type B and BW vents, Type L vents, and listed special gas vents.
4. Section 235133 "Insulated Sectional Chimneys" for listed chimney liners; listed building-heating-appliance chimneys; listed, refractory-lined metal chimneys; and field-fabricated chimneys.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of product.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For draft control fans to include in emergency, operation, and maintenance manuals.



1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of **[draft inducer fans][venturi-draft inducer fans][mechanical-draft vent fans][vent exhaust fans][combustion-air fans]** that fail in materials or workmanship within specified warranty period.
1. Failure includes failure of the fan due to corrosion.
 2. Warranty Period: **[Two][10]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DRAFT INDUCER FANS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Effikal International Inc]**
 2. **[ENERVEX Inc.]**
 3. **[Field Controls L.L.C]**
 4. **[Quickdraft]**
 5. **[Tec-Air Inc.]**
 6. **[Tjernlund Products, Inc.]**
 7. **[Wing Draft Inducers]**
 8. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Effikal International Inc]**
 2. **[ENERVEX Inc.]**
 3. **[Field Controls L.L.C]**
 4. **[Quickdraft]**
 5. **[Tec-Air Inc.]**
 6. **[Tjernlund Products, Inc.]**
 7. **[Wing Draft Inducers]**
 8. **<Insert manufacturer's name>**
- C. Fan Construction: **[Galvanized][Aluminized]**-steel housing and radial-blade centrifugal fan.
1. Fan Motor: Permanent-split-capacitor type.
- D. Controls:
1. Draft-proving switch.
 2. Control kit to cycle fan with gas flow to a single burner.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 VENTURI-DRAFT INDUCER FANS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Quickdraft]**
 2. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Quickdraft]**
 2. **<Insert manufacturer's name>**
- C. Fan Construction: Enameled-steel venturi tube for vents **20 inches (508 mm)** in diameter and smaller and ASTM A666, Type 304, stainless-steel venturi tube for vents **22 to 48 inches (559 to 1219 mm)** in diameter. **[Galvanized][Enameled]**-steel fan housing with radial-blade centrifugal wheel.
1. Fan Motor: Permanent-split-capacitor type.
- D. Controls:
1. Draft-proving switch.
 2. Control kit to cycle fan with gas flow to a single burner.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 MECHANICAL-DRAFT VENT FANS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Bradford White Corporation]**
 2. **[Effikal International Inc]**
 3. **[ENERVEX Inc.]**
 4. **[Field Controls L.L.C]**
 5. **[Quickdraft]**
 6. **[Tec-Air Inc.]**
 7. **[Tjernlund Products, Inc.]**
 8. **[Wing Draft Inducers]**
 9. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Bradford White Corporation]**
 2. **[Effikal International Inc]**
 3. **[ENERVEX Inc.]**
 4. **[Field Controls L.L.C]**
 5. **[Quickdraft]**
 6. **[Tec-Air Inc.]**
 7. **[Tjernlund Products, Inc.]**



8. **[Wing Draft Inducers]**
9. **<Insert manufacturer's name>**

C. Fan Construction: Forward-curved centrifugal fan and scroll fabricated of **[aluminized][galvanized]** steel; direct-drive, ball-bearing motor lubricated with synthetic oil; internal cooling fan; stainless-steel shaft; and integral pressure-sensing switch.

1. Fan Motor: Permanent-split-capacitor type.

D. Controls:

1. Draft-proving switch.
2. Control kit to cycle fan with gas flow to **[single][multiple]** burner(s).

E. Accessories:

1. **[Aluminized][Stainless]**-steel, wall-vent hood.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 VENT EXHAUST FANS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[ENERVEX Inc.]**
2. **[Field Controls L.L.C]**
3. **[Tjernlund Products, Inc.]**
4. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[ENERVEX Inc.]**
2. **[Field Controls L.L.C]**
3. **[Tjernlund Products, Inc.]**
4. **<Insert manufacturer's name>**

C. General: Centrifugal fan with **[variable][constant]**-speed control mounted at end of **[sidewall][vertical]** vent.

D. Test Standard: UL 378.

E. Fan Construction:

1. **[Cast-aluminum][Galvanized-steel][Stainless-steel]** housing **[painted manufacturer's standard color of baked enamel]**.
2. **[Galvanized][Stainless]**-steel vent.
3. **[Cast-aluminum][Stainless-steel]** wheel.
4. Backward-inclined centrifugal or axial fan wheel statically and dynamically balanced.
5. Access panel at the discharge area.

6. Concentric makeup air-inlet duct surrounding the vent to allow zero clearance to combustibles.
- F. Motor: Fully enclosed, [**variable-speed duty**,] permanent-split capacitor, out of the airstream, with prelubricated and sealed ball bearings.
- G. Constant-Speed Controls: Boiler interlock relay starts fan when burner control cycles on. Pressure switch permits burner operation via interlock with boiler. Fan-proving switch is adjustable between **minus 0.07- and minus 0.15-inch wg (minus 17 and minus 37 Pa)**.
- H. Variable-Speed Controls: Boiler interlock relay starts fan when burner control cycles on. Pressure controller, control transformer, and miscellaneous controls for automatic modulation of fan speed to maintain preset negative pressure between **zero- and minus 1.0-inch wg (zero and minus 249 Pa)**. Include controller with indicator lights, pressure-differential transmitter, chimney pressure-sensor probe, and fan-proving switch adjustable between **minus 0.07- and minus 0.15-inch wg (minus 17 and minus 37 Pa)**. Include tubing.
- I. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.5 COMBUSTION-AIR FANS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [ENERVEX Inc.]
 2. [Field Controls L.L.C]
 3. [Tjernlund Products, Inc.]
 4. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 1. [ENERVEX Inc.]
 2. [Field Controls L.L.C]
 3. [Tjernlund Products, Inc.]
 4. <Insert manufacturer's name>
- C. Fan Construction: [Galvanized][Aluminized]-steel housing; steel forward-curved fan and scroll; direct-drive, totally enclosed, fan-cooled motor with ball bearings; stainless-steel shaft; and integral pressure-sensing switch.
 1. Internal bypass to temper supply-air temperature to room.
- D. Controls:
 1. Fan-proving switch to permit burner operation when combustion-air fan is operating.
 2. Multiple-appliance control starts fan with operation of any one of [three][four] appliances.
 3. Modulating combustion-air fan speed to control pressure differential in room with respect to outdoors.
 4. Manual-reset, high-limit switch stops operation with **160 deg F (71 deg C)** room temperature.
 5. Optional Controls:
 - a. Alarm circuit.
 - b. Excessive negative pressure limit.

- c. Interface relay for vent exhaust fan, draft inducer fan, or mechanical-draft vent fan.
- d. **[Galvanized-steel][Aluminum]** intake hood.

- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

2.7 CAPACITIES AND CHARACTERISTICS

- A. Fan:

1. Manufacturer: **<Insert manufacturer>**.
2. Model No.: **<Insert number>**.
3. Rated Appliance Input: **<Insert Btu/h (kW)>**.
4. Airflow: **<Insert cfm (L/s)>**.
5. Speed: **<Insert value>** rpm.
6. Static Pressure: **<Insert inches wg (Pa)>**.
7. Electrical Characteristics:
 - a. Motor Horsepower: **<Insert value>**.
 - b. Volts: **[115][208][230][460]<Insert value>**.
 - c. Phase: **[Single][Three]**.
 - d. Hertz: 60.
 - e. Full-Load Amperes: **<Insert value>**.
 - f. Minimum Circuit Ampacity: **<Insert value>**.
 - g. Maximum Overcurrent Protection: **<Insert amperage>**.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install listed components in a manner complying with the listing.
- B. Install draft inducer fans in single-wall vent section that is designed to couple with other vent materials.
- C. Secure draft inducer fans to appliances, breechings, or stacks with hardware compatible with connected materials.
- D. Install draft inducer fans with clearances for service and maintenance.
- E. Install **[PVC]** intake duct that is sized according to manufacturer's written instructions.

3.2 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 23 51 13 00



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 51 13 00a - GAS VENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. UL-listed Type B double-wall vents.
2. UL-listed Type B single-wall vents.
3. UL-listed Type BW double-wall vents.
4. UL-listed Type BW single-wall vents.
5. UL-listed Type L vents.
6. UL-listed special double-wall gas vents.
7. UL-listed special single-wall gas vents.

B. Related Requirements:

1. Section 235113.11 "Draft Control Fans" for draft inducer fans, venturi-draft inducer fans, mechanical-draft vent fans, vent exhaust fans, and combustion-air fans.
2. Section 235113.16 "Vent Dampers" for motorized and barometric dampers.
3. Section 235116 "Fabricated Breechings and Accessories" for listed, refractory-lined metal breechings and field-fabricated metal breechings.
4. Section 235133 "Insulated Sectional Chimneys" for listed chimney liners; listed building-heating-appliance chimneys; listed, refractory-lined metal chimneys; and field-fabricated chimneys.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.

B. Shop Drawings: For vents.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M for hangers and supports.
2. AWS D9.1/D9.1M for shop and field welding of joints and seams in vents.

B. Certified Sizing Calculations: Manufacturer is to certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 UL-LISTED TYPE B DOUBLE-WALL VENTS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Description: Factory-fabricated UL-listed and labeled, double-wall metal vents listed and labeled in accordance with UL 441, rated for 400 deg F (204 deg C) continuously with neutral or negative flue pressure complying with NFPA 54 and NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.
- D. Inner Shell: **[ASTM B209 (ASTM B209M), Type 1100 aluminum] [ASTM B209 (ASTM B209M), Type 3003 aluminum] [ASTM B209 (ASTM B209M), Type 3105 aluminum] [or] [ASTM A666/A666M, Type 430 stainless steel].**
- E. Outer Jacket: **[Galvanized] [Aluminized]** steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 1. Termination:
 - a. Vent cap designed to avoid downdrafts and entry of rain, snow, and animals in accordance with NFPA 54 and NFPA 211.
 - b. **<Insert termination>**.

2.2 UL-LISTED TYPE B SINGLE-WALL VENTS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Description: Factory-fabricated, UL-listed and labeled, single-wall metal vents listed and labeled in accordance with UL 441, rated for 400 deg F (204 deg C) continuously with neutral or negative flue pressure complying with NFPA 54 and NFPA 211.
- C. Construction: **[ASTM B209 (ASTM B209M), Type 1100 aluminum] [ASTM B209 (ASTM B209M), Type 3003 aluminum] [ASTM B209 (ASTM B209M), Type 3105 aluminum] [or] [ASTM A666/A666M, Type 430 stainless steel].**
- D. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 1. Termination:

- a. Vent cap designed to avoid downdrafts and entry of rain, snow, and animals in accordance with NFPA 54 and NFPA 211.
- b. **<Insert termination>**.

2.3 UL-LISTED TYPE BW DOUBLE-WALL VENTS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Description: Factory-fabricated UL-listed and labeled, double-wall metal vents listed and labeled in accordance with UL 441, rated for 480 deg F (240 deg C) continuously with neutral or negative flue pressure complying with NFPA 54 and NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.
- D. Inner Shell: **[ASTM B209 (ASTM B209M), Type 1100 aluminum] [ASTM B209 (ASTM B209M), Type 3003 aluminum] [ASTM B209 (ASTM B209M), Type 3105 aluminum] [or] [ASTM A666/A666M, Type 430 stainless steel]**.
- E. Outer Jacket: **[Galvanized] [Aluminized]** steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 1. Termination:
 - a. Vent cap designed to avoid downdrafts and entry of rain, snow, and animals in accordance with NFPA 54 and NFPA 211.
 - b. **<Insert termination>**.

2.4 UL-LISTED TYPE BW SINGLE-WALL VENTS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Description: Factory-fabricated, UL-listed and labeled, single-wall metal vents listed and labeled in accordance with UL 441, rated for 480 deg F (249 deg C) continuously with neutral or negative flue pressure complying with NFPA 54 and NFPA 211.
- C. Construction: **[ASTM B209 (ASTM B209M), Type 1100 aluminum] [ASTM B209 (ASTM B209M), Type 3003 aluminum] [ASTM B209 (ASTM B209M), Type 3105 aluminum] [or] [ASTM A666/A666M, Type 430 stainless steel]**.
- D. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 1. Termination:
 - a. Vent cap designed to avoid downdrafts and entry of rain, snow, and animals in accordance with NFPA 54 and NFPA 211.
 - b. **<Insert termination>**.



2.5 UL-LISTED TYPE L VENTS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Description: Factory-fabricated, UL-listed and labeled, double-wall metal vents listed and labeled in accordance with UL 641 and rated for 570 deg F (300 deg C) continuously or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 54 and NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a **[1/4-inch (6-mm)] [1-inch (25-mm)] [2-inch (50-mm)] [4-inch (100-mm)]** airspace filled with high-temperature, **[ceramic-fiber] [mineral-wool]** insulation.
- D. Inner Shell: ASTM A666/A666M, **[Type 304] [Type 316]** stainless steel.
- E. Outer Jacket: **[Galvanized] [Aluminized] [Stainless]** steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - 1. Termination:
 - a. Vent cap designed to avoid downdrafts and entry of rain, snow, and animals in accordance with NFPA 54 and NFPA 211.
 - b. **<Insert termination>**.

2.6 UL-LISTED SPECIAL DOUBLE-WALL GAS VENTS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Description: Factory-fabricated, double-wall metal vents listed and labeled in accordance with UL 1738 and rated for **[210 deg F (99 deg C)] [300 deg F (149 deg C)] [330 deg F (177 deg C)] [400 deg F (204 deg C)] [480 deg F (249 deg C)] [550 deg F (287 deg C)]** continuously, with positive or negative flue pressure complying with NFPA 54 and NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1-inch (25-mm) airspace.
- D. Inner Shell: ASTM A959, Type AL 29-4C or other UL 1738-approved stainless steel suitable for the application.
- E. Outer Jacket: **[Aluminized] [Stainless]** steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - 1. Termination:
 - a. Vent cap designed to avoid downdrafts and entry of rain, snow, and animals in accordance with NFPA 54 and NFPA 211.
 - b. **<Insert termination>**.



2.7 UL-LISTED SPECIAL SINGLE-WALL GAS VENTS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Description: Factory-fabricated, UL-listed and labeled, single-wall metal vents listed and labeled in accordance with UL 1738 and rated for **[210 deg F (99 deg C)] [300 deg F (149 deg C)] [330 deg F (177 deg C)] [400 deg F (204 deg C)] [480 deg F (249 deg C)] [550 deg F (287 deg C)]** continuously, with positive or negative flue pressure complying with NFPA 54 and NFPA 211.
- C. Construction: ASTM A959, Type AL 29-4C or other UL 1738-approved stainless steel.
- D. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - 1. Termination:
 - a. Vent cap designed to avoid downdrafts and entry of rain, snow, and animals in accordance with NFPA 54 and NFPA 211.
 - b. **<Insert termination>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

- A. Listed Type B and Type BW Vents: Vents for certified gas appliances.
- B. Listed Type L Vent: Vents for low-heat appliances.
- C. Listed Special Gas Vent: Condensing gas appliances.

3.3 INSTALLATION OF UL-LISTED VENTS

- A. Install all vent systems in accordance with vent system component manufacturer's written instructions and associated appliance manufacturer's written instructions.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
- C. Comply with minimum clearances from combustibles and minimum termination heights in accordance with product listing or NFPA 54[, and **NFPA 31**,] whichever is most stringent.
- D. Seal between sections of positive-pressure vents in accordance with manufacturer's written installation instructions, using sealants recommended by manufacturer.

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



- E. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
- F. Lap joints in direction of flow.

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 23 51 13 00a

SECTION 23 51 13 00b - INSULATED SECTIONAL CHIMNEYS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. UL-listed chimney liners.
2. UL-listed building-heating-appliance chimney - 1000 deg F (538 deg C).
3. UL-listed building-heating-appliance chimney - 1400 deg F (760 deg C).
4. UL-listed building-heating-appliance chimney - Type HT.
5. Field-fabricated metal chimneys.
6. Guying and bracing materials.

B. Related Requirements:

1. Section 235113.11 "Draft Control Fans" for draft inducer fans, venturi-draft inducer fans, mechanical-draft vent fans, vent exhaust fans, and combustion-air fans.
2. Section 235113.16 "Vent Dampers" for motorized and barometric dampers.
3. Section 235116 "Fabricated Breechings and Accessories" for UL-listed, refractory-lined metal breechings and field-fabricated metal breechings.
4. Section 235123 "Gas Vents" for Type B and Type BW vents, Type L vents, and UL-listed special gas vents.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles and finishes for product.

B. Shop Drawings: For chimneys and stacks.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Seismic Qualification Certificates: For factory-fabricated chimneys and stacks, accessories, and components from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Sample Warranty: For special warranty.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M for hangers and supports.
2. AWS D9.1/D9.1M for shop and field welding of joints and seams in stacks.

B. Certified Sizing Calculations: Manufacturer to certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 UL-LISTED CHIMNEY LINERS

A. UL-Listed Chimney Liners:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description, Gas-Fuel-Fired: **[Rigid] [Flexible]**, single-wall chimney liner UL-listed and labeled in accordance with UL 1777 and rated for 470 deg F (243 deg C) for gas-fired appliances with negative or positive flue pressure complying with NFPA 54 and NFPA 211.
3. Description, Oil-Fuel-Fired: **[Rigid] [Flexible]**, single-wall chimney liner UL-listed and labeled in accordance with UL 1777 and rated for 570 deg F (300 deg C) for oil-fired appliances with negative or positive flue pressure complying with NFPA 54 and NFPA 211.
4. Description, Gas/Oil-Fuel-Fired Combination: **[Rigid] [Flexible]**, single-wall chimney liner UL-listed and labeled in accordance with UL 1777 and rated for 570 deg F (300 deg C) for combination gas/oil-fired appliances with negative or positive flue pressure complying with NFPA 54 and NFPA 211.
5. Description, Solid-Fuel-Fired: **[Rigid] [Flexible]**, single-wall chimney liner tested, listed, and labeled in accordance with UL 1777 and rated for 1000 deg F (538 deg C) continuously and for 2100 deg F (1150 deg C) for 10 minutes for solid-fuel-fired appliances with negative or positive flue pressure complying with NFPA 54 and NFPA 211.
6. Rigid Liner Materials: ASTM A666/A666M, **[Type 304] [Type 316] [Type 430] [or] [Type 446]** stainless steel.
7. Flexible Liner Materials: **[ASTM A240/A240M, Type 321] [ASTM A240/A240M, Type 430] [or] [ASTM A959, Type 29-4C]** stainless steel.
8. Accessories:
 - a. Fittings: Tees, elbows, increasers, draft-hood connectors, metal caps with bird barriers, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar or compatible materials and designs.
 - b. Sealant: Manufacturer's standard high-temperature sealant.
 - c. Insulating Fill: Manufacturer's standard high-temperature insulation fill material in annular space surrounding chimney liner, including high-temperature, ceramic-fiber insulation required to seal chimney at top and bottom.
 - d. Termination:

- 1) Vent cap designed to avoid downdrafts and entry of rain, snow, and animals in accordance with NFPA 54 and NFPA 211.
- 2) **<Insert termination>**.

B. UL-Listed Building-Heating-Appliance Chimney - 1000 deg F (538 deg C):

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Double-wall metal vents UL-listed and labeled in accordance with UL 103 and rated for 1000 deg F (538 deg C) continuously; with neutral or negative flue pressure complying with NFPA 54 and NFPA 211.
3. Construction: Inner shell and outer jacket separated by at least a **[1/2-inch (25-mm)] [1-inch (50-mm)] [2-inch (50-mm)] [3-inch (75-mm)] [4-inch (100-mm)]** annular space **[filled with high-temperature, ceramic-fiber insulation]**.
4. Inner Shell: ASTM A666/A666M, **[Type 304] [Type 316]** stainless steel.
5. Outer Jacket: **[Galvanized] [Aluminized] [ASTM A666/A666M stainless]** steel.
6. Accessories:
 - a. Fittings: Tees, elbows, increasers, draft-hood connectors, metal caps with bird barriers, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar or compatible materials and designs.
 - b. Termination:
 - 1) Vent cap designed to avoid downdrafts and entry of rain, snow, and animals in accordance with NFPA 54 and NFPA 211.
 - 2) **<Insert termination>**.

C. UL-Listed Building-Heating-Appliance Chimney - 1400 deg F (760 deg C):

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Double-wall metal vents tested, listed, and labeled in accordance with UL 103 and UL 2561 and rated for 1400 deg F (760 deg C) continuously; with positive or negative flue pressure complying with NFPA 54 and NFPA 211.
3. Construction: Inner shell and outer jacket separated by at least a **[1-inch (25-mm)] [2-inch (50-mm)] [3-inch (75-mm)] [4-inch (100-mm)]** annular space filled with high-temperature, ceramic-fiber insulation.
4. Inner Shell: ASTM A666/A666M, **[Type 304] [Type 316]** stainless steel.
5. Outer Jacket: **[Galvanized] [Aluminized] [ASTM A666/A666M stainless]** steel.
6. Accessories:
 - a. Fittings: Tees, elbows, increasers, draft-hood connectors, metal caps with bird barriers, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar or compatible materials and designs.
 - b. Termination:
 - 1) Vent cap designed to avoid downdrafts and entry of rain, snow, and animals in accordance with NFPA 54 and NFPA 211.
 - 2) **<Insert termination>**.

D. UL-Listed Building-Heating-Appliance Chimney - Type HT:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Double-wall metal vents tested, listed, and labeled in accordance with UL 103 and rated for 1000 deg F (538 deg C) continuously and for 2100 deg F (1150 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 54 and NFPA 211.

3. Construction: Inner shell and outer jacket separated by at least a [1-inch (25-mm)] [1-1/2-inch (38-mm)] [2-inch (50-mm)] [4-inch (100-mm)] annular space filled with high-temperature, ceramic-fiber insulation.
4. Inner Shell: [ASTM A666/A666M, Type 304] [ASTM A666/A666M, Type 316] [ASTM A240/A240M, Type 430] stainless steel.
5. Outer Jacket: [Galvanized] [Aluminized] [ASTM A666/A666M stainless] steel.
6. Accessories:
 - a. Fittings: Tees, elbows, increasers, draft-hood connectors, metal caps with bird barriers, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar or compatible materials and designs.
 - b. Sealant: Manufacturer's standard high-temperature sealant.
 - c. Insulating Fill: Manufacturer's standard high-temperature insulation fill material in annular space surrounding chimney liner, including high-temperature, ceramic-fiber insulation required to seal chimney at top and bottom.
 - d. Termination:
 - 1) Vent cap designed to avoid downdrafts and entry of rain, snow, and animals in accordance with NFPA 54 and NFPA 211.
 - 2) <Insert termination>.

2.2 FIELD-FABRICATED METAL CHIMNEYS

- A. Fabricate freestanding chimneys in accordance with SMACNA's "Guide for Free Standing Steel Stack Construction." Design for minimum <Insert ft. (m)> high and <Insert inches (mm)> in diameter.
- B. Fabricate chimneys from ASTM A1011/A1011M hot-rolled steel with continuously welded joints, complying with NFPA 54 and NFPA 211 for minimum metal thickness.
 1. Equal to or Less Than 1.069 Sq. Ft. (0.099 Sq. m.) or 14 Inches (356 mm) in Diameter: 0.053 inch (1.35 mm).
 2. Up to 1.396 Sq. Ft. (0.129 Sq. m) or 16 Inches (406 mm) in Diameter: 0.067 inch (1.7 mm).
 3. Up to 1.764 Sq. Ft. (0.164 Sq. m.) or 18 Inches (457 mm) in Diameter: 0.093 inch (2.36 mm).
 4. Larger than 18 Inches (457 mm) in Diameter: 0.123 inch (3.124 mm).
- C. Fabricate chimneys and vent connectors from galvanized steel, complying with NFPA 54 and NFPA 211 for minimum metal thickness.
 1. Equal to or Less Than 6 Inches (152 mm) in Diameter: 0.019 inch (0.48 mm).
 2. Up to 10 Inches (254 mm) in Diameter: 0.024 inch (0.61 mm).
 3. Up to 16 Inches (406 mm) in Diameter: 0.029 inch (0.74 mm).
 4. Larger than 16 Inches (406 mm) in Diameter: 0.056 inch (1.42 mm).
- D. Fabricate chimneys and vent connectors from ASTM B209 (ASTM B209M), Type 1100 or Type 3003, aluminum or stainless steel, complying with NFPA 54 and NFPA 211 for the following minimum metal thicknesses:
 1. Aluminum: 0.027 inch (0.69 mm).
 2. Stainless Steel: 0.012 inch (0.31 mm).
- E. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and gasketed.
 1. Gasket: Fiberglass rope.

- F. Fabricate engine exhaust from ASTM A53/A53M, Type E (electric-resistance welded), Grade B; or ASTM A106/A106M, Type S, Grade B, **[Schedule 40] [Schedule 80]** pipe; with welded joints and carbon-steel fittings and flanges.
1. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
 2. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150, including bolts, nuts, and fiberglass gaskets.

2.3 GUYING AND BRACING MATERIALS

- A. See Drawings for guying and bracing design and details.
- B. Guying and Bracing Materials:
1. Cable: Galvanized, stranded wires of the following thickness:
 - a. Minimum Size: 1/4 inch (6 mm) in diameter.
 - b. Minimum Size for Chimney ID Sizes 4 to 15 Inches (100 to 381 mm): 5/16 inch (8 mm).
 - c. Minimum Size for Chimney ID Sizes 18 to 24 Inches (457 to 610 mm): 3/8 inch (9.5 mm).
 - d. Minimum Size for Chimney ID Sizes 27 to 30 Inches (685 to 762 mm): 7/16 inch (11 mm).
 - e. Minimum Size for Chimney ID Sizes 33 to 36 Inches (838 to 915 mm): 1/2 inch (13 mm).
 - f. Minimum Size for Chimney ID Sizes 39 to 48 Inches (990 to 1220 mm): 9/16 inch (14.3 mm).
 - g. Minimum Size for Chimney ID Sizes 51 to 60 Inches (1295 to 1524 mm): 5/8 inch (16 mm).
 2. Pipe: Galvanized steel, minimum **[NPS 1-1/4 (DN 32)] <Insert size>**.
 3. Angle Iron: Galvanized steel, minimum **[2 by 2 by 0.25 inch (50 by 50 by 6 mm)] <Insert size>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

- A. UL-Listed Chimney Liners: High-efficiency **[boiler] [or] [furnace]** stacks in masonry chimney.
- B. UL-Listed Building-Heating-Appliance Chimney - 1000 deg F (538 deg C): **[Dual-fuel boilers,] [oven vents,] [water heaters,] [and] [engine exhausts]**.
- C. UL-Listed Building-Heating-Appliance Chimney - 1400 deg F (760 deg C): **[Dual-fuel boilers,] [oven vents,] [water heaters,] [and] [engine exhausts]**.
- D. UL-listed Building-Heating-Appliance Chimney - Type HT: **[Fireplaces] <Insert other solid-fuel-burning appliance>**.



- E. Field-Fabricated Metal Chimneys: [Dual-fuel boilers,] [oven vents,] [water heaters,] [engine exhausts,] [and] [fireplaces,] <Insert other solid-fuel-burning appliance>.
- F. <Insert chimney type and application.>

3.3 INSTALLATION OF UL-LISTED CHIMNEYS

- A. Install chimneys in accordance with chimney and components manufacturer's written instructions, associated appliance manufacturer's written instructions, NFPA 31, NFPA 54, NFPA 211, and AHJ requirements.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for concrete, reinforcement, and formwork.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
- D. Comply with minimum clearances from combustibles and minimum termination heights in accordance with product listing, NFPA 54, or NFPA 211, whichever is most stringent.
- E. Seal between sections of positive-pressure vents in accordance with manufacturer's written installation instructions, using sealants recommended by manufacturer.
- F. Lap joints in direction of flow.

3.4 INSTALLATION OF FIELD-FABRICATED METAL CHIMNEYS

- A. Suspend chimneys independent of their appliance connections.
- B. Install seismic restraints in accordance with manufacturer's written instructions. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC."
- C. Lap joints in direction of flow.
- D. Support chimneys from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C clamps, or beam clamps in accordance with manufacturer's written instructions.

3.5 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.
- B. Provide temporary closures at ends of chimneys and stacks that are not completed or connected to equipment.

END OF SECTION 23 51 13 00b



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 51 13 13	23 51 13 00	Draft Control Fans
23 51 13 13	23 51 16 00	Fabricated Breechings and Accessories
23 51 13 13	23 51 13 00a	Gas Vents
23 51 13 13	23 51 13 00b	Insulated Sectional Chimneys



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 51 13 16 - VENT DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Barometric dampers.
2. Vent dampers.

B. Related Requirements:

1. Section 235113.11 "Draft Control Fans" for draft inducer fans, venturi-draft inducer fans, mechanical-draft vent fans, vent exhaust fans, and combustion-air fans.
2. Section 235116 "Fabricated Breechings and Accessories" for listed, refractory-lined metal breechings and field-fabricated metal breechings.
3. Section 235123 "Gas Vents" for Type B and BW vents, Type L vents, and listed special gas vents.
4. Section 235133 "Insulated Sectional Chimneys" for listed chimney liners; listed building-heating-appliance chimneys; listed, refractory-lined metal chimneys; and field-fabricated chimneys.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of product.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For draft control devices to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of **[barometric dampers][vent dampers]** that fail in materials or workmanship within specified warranty period.

1. Failure includes failure due to corrosion.
2. Warranty Period: [Two][10]<Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 BAROMETRIC DAMPERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. [Effikal International Inc]
 2. [ENERVEX Inc.]
 3. [FAMCO]
 4. [Field Controls L.L.C]
 5. [Quickdraft]
 6. [Snappy Air Distribution Products]
 7. [Tec-Air Inc.]
 8. [Tjernlund Products, Inc.]
 9. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Effikal International Inc]
 2. [ENERVEX Inc.]
 3. [FAMCO]
 4. [Field Controls L.L.C]
 5. [Quickdraft]
 6. [Snappy Air Distribution Products]
 7. [Tec-Air Inc.]
 8. [Tjernlund Products, Inc.]
 9. <Insert manufacturer's name>
- C. Damper Construction: High-temperature-enamel-painted steel damper and housing with galvanized-steel breeching connection. Adjustable counterweight with lock. Include knife-edge bearings that do not require lubrication.

2.2 VENT DAMPERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. [Effikal International Inc]
 2. [Field Controls L.L.C]
 3. [Johnson Controls, Inc.]
 4. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Effikal International Inc]
2. [Field Controls L.L.C]
3. [Johnson Controls, Inc.]
4. <Insert manufacturer's name>

C. Damper Construction: Stainless steel damper blade, shaft, and vent pipe with metal, prelubricated bearings.

1. Electric motor sized to power damper open and closed in approximately 15 seconds in each direction. Power is off when damper is at rest.
2. Comply with ANSI Z21.66.

D. Controls:

1. Control transformer.
2. Keyed wiring harness.
3. Damper end switch to prove damper is open.
4. Interlock with boiler to permit burner operation when damper is open.
5. Hold-open switch for troubleshooting boiler controls.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

2.4 CAPACITIES AND CHARACTERISTICS

A. Damper:

1. Manufacturer: <Insert manufacturer>.
2. Model No.: <Insert number>.
3. Rated Appliance Input: <Insert Btu/h (kW)>.
4. Vent Size: <Insert inches (mm)>.
5. Electrical Characteristics:
 - a. Motor Horsepower: <Insert value>.
 - b. Volts: [115]<Insert value>.
 - c. Phase: Single.
 - d. Hertz: 60.
 - e. Full-Load Amperes: <Insert value>.
 - f. Minimum Circuit Ampacity: <Insert value>.
 - g. Maximum Overcurrent Protection: <Insert amperage>.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install listed components in a manner complying with the listing.
- B. Secure barometric dampers to breechings with hardware compatible with connected materials.

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



- C. Locate barometric and motorized vent dampers as close to draft hood collar as possible.
- D. Secure barometric and motorized vent dampers to appliances, breechings, or chimneys with hardware compatible with connected materials.

3.2 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 23 51 13 16



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 51 13 16	23 51 13 00	Draft Control Fans
23 51 13 16	23 51 16 00	Fabricated Breechings and Accessories
23 51 13 16	23 51 13 00a	Gas Vents
23 51 13 16	23 51 13 00b	Insulated Sectional Chimneys
23 51 13 19	23 33 00 00	Air Duct Accessories
23 51 13 19	23 51 13 00	Draft Control Fans
23 51 13 19	23 51 13 00a	Gas Vents
23 51 13 19	23 51 13 00b	Insulated Sectional Chimneys



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 51 16 00 - FABRICATED BREECHINGS AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Listed, refractory-lined breechings.
2. Field-fabricated metal breechings.
3. Guying and bracing materials.

B. Related Requirements:

1. Section 235113.11 "Draft Control Fans" for draft inducer fans, venturi-draft inducer fans, mechanical-draft vent fans, vent exhaust fans, and combustion-air fans.
2. Section 235113.16 "Vent Dampers" for motorized and barometric dampers.
3. Section 235123 "Gas Vents" for Type B and BW vents, Type L vents, and listed special gas vents.
4. Section 235133 "Insulated Sectional Chimneys" for listed chimney liners; listed building-heating-appliance chimneys; listed, refractory-lined metal chimneys; and field-fabricated chimneys.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.

B. Shop Drawings: For breechings.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Seismic Qualification Certificates: For factory-fabricated breeching, accessories, and components from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.



- C. Sample Warranty: For special warranty.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 - 2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in breechings.
- B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, structural failures caused by expansion and contraction.
 - 2. Warranty Period: **[10][15][25]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LISTED, REFRACTORY-LINED METAL BREECHINGS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Van-Packer Co.]**
 - 2. **[Warren Environment, Inc]**
 - 3. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Van-Packer Co.]**
 - 2. **[Warren Environment, Inc]**
 - 3. **<Insert manufacturer's name>**
- C. Comply with ASME STS-1.
- D. Design Wind Loads: **[150 mph (241 km/h)]<Insert wind speed>**.
- E. Design for seismic conditions at Project site.
- F. Refractory Lining: Tested according to UL 959 for temperature and acid resistance and bearing the testing laboratory label.
 - 1. Temperature Rating: **1800 deg F (982 deg C)** continuously and **2000 deg F (1093 deg C)** intermittently.

2. Acid Extraction: Maximum of 0.2 percent.
 3. Cold Crushing Strength: Minimum of **3200 psig (22 MPa)**.
 4. Thickness: Minimum of **2 inches (50 mm)**.
- G. Finish: Factory-applied, high-heat-resistant paint; color as selected by Architect.

2.2 FIELD-FABRICATED METAL BREECHINGS

- A. Fabricate breechings from ASTM A1011/A1011M hot-rolled steel with continuously welded joints, complying with NFPA 211 for minimum metal thickness.
1. Equal to or Less Than **1.069 Sq. Ft. (0.099 Sq. m.)** or **14 Inches (356 mm)** in Diameter: **0.053 inch (1.35 mm)**.
 2. Up to **1.396 Sq. Ft. (0.129 Sq. m.)** or **16 Inches (406 mm)** in Diameter: **0.067 inch (1.7 mm)**.
 3. Up to **1.764 Sq. Ft. (0.164 Sq. m.)** or **18 Inches (457 mm)** in Diameter: **0.093 inch (2.36 mm)**.
 4. Larger Than **1.764 Sq. Ft. (0.164 Sq. m.)** or **18 Inches (457 mm)** in Diameter: **0.123 inch (3.12 mm)**.
- B. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and gasketed.
- C. Fabricate engine exhaust from ASTM A53/A53M, Type E (electric-resistance welded), Grade B; or ASTM A106/A106M, Type S, Grade B, **[Schedule 40][Schedule 80]** pipe; with welded joints and carbon-steel fittings and flanges.
1. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
 2. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150, including bolts, nuts, and gaskets.

2.3 GUYING AND BRACING MATERIALS

- A. Cable: **[Three][Four]<Insert number>** galvanized, stranded wires of the following thickness:
1. Minimum Size: **1/4 inch (6 mm)** in diameter.
 2. For ID Sizes **4 to 15 Inches (100 to 381 mm)**: **5/16 inch (8 mm)**.
 3. For ID Sizes **18 to 24 Inches (457 to 610 mm)**: **3/8 inch (9.5 mm)**.
 4. For ID Sizes **27 to 30 Inches (685 to 762 mm)**: **7/16 inch (11 mm)**.
 5. For ID Sizes **33 to 36 Inches (838 to 915 mm)**: **1/2 inch (13 mm)**.
 6. For ID Sizes **39 to 48 Inches (990 to 1220 mm)**: **9/16 inch (14.3 mm)**.
 7. For ID Sizes **51 to 60 Inches (1295 to 1524 mm)**: **5/8 inch (16 mm)**.
- B. Pipe: **[Two][Three]<Insert number>** galvanized steel, **NPS 1-1/4 (DN 32)**.
- C. Angle Iron: **[Two][Three]<Insert number>** galvanized steel, **2 by 2 by 0.25 inch (50 by 50 by 6 mm)**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of Work.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

- A. Listed, Refractory-Lined Metal Breechings: Freestanding dual-fuel boiler vents, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.
- B. Field-Fabricated Metal Breechings: Dual-fuel boilers, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.

3.3 INSTALLATION OF UNLISTED, FIELD-FABRICATED BREECHINGS

- A. Suspend breechings independent of their appliance connections.
- B. Install seismic restrains according to manufacturer's written instructions. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC."
- C. Align breechings at connections, with smooth internal surface and a maximum **1/8-inch (3-mm)** misalignment tolerance.
- D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
- E. Lap joints in direction of flow.
- F. Support breechings from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C clamps, or beam clamps according to manufacturer's written instructions.

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.
- B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.
- C. Provide temporary closures at ends of breechings that are not completed or connected to equipment.

END OF SECTION 23 51 16 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 51 16 00	23 51 13 00a	Gas Vents
23 51 16 00	23 51 13 00b	Insulated Sectional Chimneys



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 52 13 00 - ELECTRIC BOILERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes electric boilers, trim, and accessories for generating [hot water][and][steam].

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: For energy performance.
- C. Shop Drawings: For boilers, boiler trim, and accessories.
 - 1. Include plans, elevations, sections, and [mounting][attachment] details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- D. Delegated-Design Submittal: For each boiler.
 - 1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for boilers, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- B. Source quality-control reports.
- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.
- E. Other Informational Submittals:
 - 1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
 - 2. CSA B51 pressure vessel Canadian Registration Number (CRN).
 - 3. Startup service reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For boilers, components, and accessories to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace pressure vessels of boilers that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: **[Five]**<Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ELECTRIC BOILERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Acme Engineering Products Inc]**
 - 2. **[Argo Technology, Inc.]**
 - 3. **[Benjamin Heating Products]**
 - 4. **[Bryan Boilers; Bryan Steam LLC]**
 - 5. **[Cleaver-Brooks]**
 - 6. **[Fulton Boiler Works, Inc]**
 - 7. **[Lattner Boiler Manufacturing]**
 - 8. **[Lion Boilers; a division of Concept Manufacturing Inc.]**
 - 9. **[Lochinvar, LLC]**
 - 10. **[Patterson-Kelley]**
 - 11. **[Precision Boilers]**
 - 12. **[PVI; A WATTS Brand]**
 - 13. **[Reimers Electra Steam, Inc]**
 - 14. **[Sussman Electric Boilers]**
 - 15. **[Thermon, Inc.]**
 - 16. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Acme Engineering Products Inc]**
2. **[Argo Technology, Inc.]**
3. **[Benjamin Heating Products]**
4. **[Bryan Boilers; Bryan Steam LLC]**
5. **[Cleaver-Brooks]**
6. **[Fulton Boiler Works, Inc]**
7. **[Lattner Boiler Manufacturing]**
8. **[Lion Boilers; a division of Concept Manufacturing Inc.]**
9. **[Lochinvar, LLC]**
10. **[Patterson-Kelley]**
11. **[Precision Boilers]**
12. **[PVI; A WATTS Brand]**
13. **[Reimers Electra Steam, Inc]**
14. **[Sussman Electric Boilers]**
15. **[Thermon, Inc.]**
16. **<Insert manufacturer's name>**

2.2 MANUFACTURED UNITS

- A. Description: Factory-fabricated, -assembled, and -tested electric boilers with trim and controls necessary to generate **[hot water][steam]**.
- B. Pressure Vessel: **[Carbon-steel][Cast-iron]** pressure vessel mounted on structural-steel base.
- C. Nozzles: Flanges for **[water inlet and][steam]** outlet and heating element inserts; threaded connections for trim and controls.
- D. Insulation: **[One layer][Two layers]** of minimum **[1-inch- (25-mm-)][2-inch- (50-mm-)]<Insert thickness>** thick, glass-fiber insulation.
- E. Jacket: **[Galvanized]** sheet metal casing with **[baked-enamel][powder-coated]** protective finish and removable panels with snap-in or interlocking closures for access to pressure vessel.
- F. Lifting Lugs: Welded to pressure vessel, extending above jacket.
- G. Heating Elements: **[Copper][Incoloy]**-sheathed, replaceable electric-resistance element, rated 20-kW maximum, with maximum **[50 W/sq. in. (7.7 W/sq. cm)][75 W/sq. in. (11.5 W/sq. cm)]<Insert value>** over heat-transfer length.
- H. Mounting Base: For securing boiler to concrete base.
1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.
- I. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- J. ASME Compliance: Fabricate and label boilers to comply with 2013 ASME Boiler and Pressure Vessel Code.



- K. NFPA Compliance: Design and fabricate boilers to comply with NFPA 70, Article 424, Paragraphs G and H.
- L. UL Compliance: Test boilers for compliance with UL 834. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- M. CSA Compliance: Test boilers for compliance with CSA B51.

2.3 TRIM FOR HOT-WATER BOILERS

- A. Include devices sized to comply with **[ASME B31.1][ASME B31.9][CSA B51]**.
- B. Aquastat Controllers: Operating auto-reset high limit.
- C. Safety Relief Valve: ASME rated.
- D. Pressure and Temperature Gage: Minimum **3-1/2-inch- (89-mm-)** diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.
- E. Boiler Air Vent: **[Automatic][Manual]**.
- F. Dip-tube in water outlet.
- G. Drain Valve: Minimum **NPS 3/4 (DN 20)** hose-end ball valve sized according to requirements of authorities having jurisdiction.
- H. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of pressure vessel and sealed with fiber gasket.
 - 1. Tappings **NPS 2 (DN 50)** and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - 2. Tappings **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

2.4 TRIM FOR STEAM BOILERS

- A. Include devices sized to comply with **[ASME B31.1][ASME B31.9][CSA B51]**.
- B. Pressure Controllers: Operating auto-reset high limit.
- C. Safety Relief Valve:
 - 1. Size and Capacity: As required for equipment according to 2013 ASME Boiler and Pressure Vessel Code.
 - 2. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
 - a. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet, with threads complying with ASME B1.20.1.
- D. Pressure Gage: Minimum **3-1/2-inch (89-mm)** diameter. Gage shall have normal operating pressure

about 50 percent of full range.

- E. Water Column: Minimum **12-inch (300-mm)** glass gage with shutoff cocks.
- F. Drain Valves: Minimum **NPS 3/4 (DN 20)** or nozzle size with hose-end connection.
- G. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle. [**Blowdown valves shall be combination of slow and quick acting, as required by ASME B31.1.**]
- H. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than **NPS 2 (DN 50)** shall have rising stem.
- I. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet, with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
- J. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of pressure vessel and sealed with fiber gasket.
 - 1. Tappings **NPS 2 (DN 50)** and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - 2. Tappings **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

2.5 CONTROLS

- A. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- B. Boiler operating controls shall include the following devices and features:
 - 1. Control transformer.
 - 2. Step controller.
 - 3. Recycling relay returns controller to off position after power failure.
 - 4. Multistage thermostat.
 - 5. Control-circuit switch.
 - 6. Visual indication for each step.
 - 7. Supply-voltage indicator.
 - 8. Set-Point Adjust: Set points shall be adjustable.
 - 9. Operating Level Control: Factory wired and mounted to cycle feedwater pump(s) for makeup water control.
 - 10. Sequence of Operation:
 - a. Electric, factory-fabricated and field-installed panel to control element sequence controller to maintain space temperature in response to thermostat with heat anticipator located in heated space.
 - 1) Include automatic, alternating-operation sequence for multiple boilers to provide equal runtime for boilers.
 - b. Electric, factory-fabricated and field-installed panel to control element sequence controller to reset supply-water temperature inversely with outside-air temperature. At [0 deg F (minus 17 deg C)]<Insert temperature> outside-air temperature, set supply-water temperature at [200 deg F (93 deg C)]<Insert temperature>; at [60 deg F (15

deg C)]<Insert temperature> outside-air temperature, set supply-water temperature at [140 deg F (60 deg C)]<Insert temperature>.

- 1) Include automatic, alternating-operation sequence for multiple boilers to provide equal runtime for boilers.
- c. Electric, factory-fabricated and field-installed panel to control element sequence controller to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
 - 1) Include automatic, alternating-operation sequence for multiple boilers to provide equal runtime for boilers.
- C. Safety Controls: To maintain safe operating conditions, safety controls limit boiler operation.
 1. High Cutoff: [Manual][Automatic] reset stops boiler if operating conditions rise above set point or maximum boiler design [temperature][pressure].
 2. Low-Water Cutoff Switch: [Electronic][Float and electronic] probe shall prevent boiler operation on low water. Cutoff switch shall be [manual][automatic]-reset type.
 3. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
- D. Building Management System Interface: Factory install hardware and software to enable building management system to monitor, control, and display boiler status and alarms.
 1. Hardwired Points:
 - a. Monitoring: On/off status, [common trouble alarm][low-water-level alarm]<Insert monitoring>.
 - b. Control: On/off operation, [hot water supply temperature set-point adjustment][steam pressure adjustment]<Insert control>.
 2. A communication interface with building management system shall enable building management system operator to remotely control and monitor the boiler from an operator workstation. Control features available and monitoring points displayed locally at boiler control panel shall be available through building management system.

2.6 ELECTRICAL POWER

- A. Single-Point Field Power Connection: Factory-installed and -wired switches, transformers, and electrical devices necessary shall provide a single-point field power connection to boiler.
 1. Field power interface shall be to [fused disconnect switch][nonfused disconnect switch][circuit breaker].
 2. Interlock with door to de-energize power with door open.
- B. Electrical Enclosures: NEMA 250, Type [1]<Insert type> enclosure with hinged door and key-locking handle.
- C. Install factory wiring outside of an enclosure in a [metal]raceway.
- D. Comply with NFPA 70.

1. Electrical Circuits: 48 A, maximum.
- E. Connectors: Mechanical lugs bolted to copper bus bars or distribution blocks with pressure connectors.
- F. Fuses: NEMA FU 1, Class J or K5; 60 A, maximum.
- G. Contactors: Three-pole magnetic contactors, listed for 500,000 cycles at full load.
- H. Factory-wired internal control devices and heating elements.
 1. Wiring shall be numbered and color coded to match wiring diagram.

2.7 CAPACITIES AND CHARACTERISTICS

- A. Hot-Water Heating:
 1. Design Water-Pressure Rating: **[160 psig (1100 kPa)]<Insert pressure rating>**.
 2. Safety Relief Valve Setting: **<Insert psig (kPa)>**.
 3. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 4. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
 5. Design Water Flow Rate: **<Insert gpm (L/s)>**.
 6. Design Pressure Drop: **<Insert psig (kPa)>**.
- B. Steam Heating:
 1. Design Steam-Pressure Rating: **[15 psig (104 kPa)][60 psig (420 kPa)][125 psig (860 kPa)]<Insert pressure rating>**.
 2. Safety Relief Valve Setting: **<Insert psig (kPa)>**.
 3. Steam Operating Pressure: **<Insert psig (kPa)>**.
 4. Steam Flow Rate: **<Insert lb/h (kg/s)>**.
- C. Output Capacity: **<Insert MBh (kW)>**.
- D. Equivalent Direct Radiation: **<Insert EDR (W)>**.
- E. Tankless Water Heater:
 1. Design Water Flow: **<Insert gpm (L/s)>**.
 2. Design Pressure Drop: **<Insert psig (kPa)>**.
 3. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 4. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
- F. Electrical Characteristics:
 1. Kilowatts: **<Insert number> kW**.
 2. Volts: **[208][480]<Insert number> V**.
 3. Phase: Three.
 4. Hertz: **[50][60]<Insert number> Hz**.
 5. Full-Load Amperes: **<Insert number> A**.
 6. Minimum Circuit Ampacity: **<Insert number> A**.
 7. Maximum Overcurrent Protection: **<Insert number> A**.



2.8 SOURCE QUALITY CONTROL

- A. Test and inspect factory-assembled boilers, before shipping, according to **[2013 ASME Boiler and Pressure Vessel Code][CSA B51]**.
- B. Hydrostatic Test: Factory test assembled boiler, including hydrostatic test.
- C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.
 - 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical spaces, including required space for element removal, for suitable conditions where boilers will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

- A. Equipment Mounting:
 - 1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in **[Section 232113 "Hydronic Piping"]****[and][Section 232213 "Steam and Condensate Heating Piping."]** Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to boiler to allow service and maintenance.
- C. Connect hot-water piping to supply- and return-boiler tapings, with shutoff valve and union or flange at each connection.

- D. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings, with shutoff valve and union or flange at each connection.
- E. Install piping from safety relief valves to nearest floor drain.
- F. Install piping from safety relief valves to drip-pan elbow and to nearest floor drain.
- G. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Check and adjust initial operating set points and high- and low-limit safety set points of water level and **[water temperature][steam pressure]**.
 - b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Performance Tests:
 - 1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - 2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment in order to comply.
 - 3. Perform field performance tests to determine the capacity of boilers.
 - 4. Repeat tests until results comply with requirements indicated.
 - 5. Provide analysis equipment required to determine performance.
 - 6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
 - 7. Notify Architect in advance of test dates.
 - 8. Document test results in a report and submit to Architect.
- F. Boiler will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within **[12 months]<Insert time period>** of date of

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 23 52 13 00



SECTION 23 52 16 00 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pulse-combustion, fire-tube condensing boilers.
2. Floor-mounted, forced-draft, fire-tube condensing boilers.
3. Wall-hung, forced-draft, fire-tube condensing boilers.
4. Water-jacketed condensing boilers.
5. Condensate-neutralization units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 90.1.

C. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For each boiler.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:** Plans and sections, drawn to scale and coordinated with each other, using input from installers of the items involved.



- B. Seismic Qualification Data: Certificates, for boiler, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Source quality-control reports.
- D. Field quality-control reports.
- E. Sample Warranty: For special warranty.
- F. Product Certificates:
 - 1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
 - 2. CSA B51 pressure vessel Canadian Registration Number (CRN).

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period. Where "prorated" is indicated, the boiler manufacturer will cover the indicated percentage of cost of replacement parts. With "prorated" type, covered cost decreases as age of equipment increases.
 - 1. Warranty Period for Pulse-Combustion Boilers:
 - a. Heat Exchanger Damaged by Thermal Shock: [10]<Insert number> years from date of Substantial Completion.
 - b. Flue-Gas Condensate Corrosion of Heat Exchanger: **[Prorated Year 0 to 7 - 100 percent; Year 8 - 50 percent; Year 9 - 30 percent; Year 10 - 20 percent]**[Nonprorated] for [10]<Insert number> years from date of Substantial Completion.
 - 2. Warranty Period for Floor-Mounted Fire-Tube Condensing Boilers:
 - a. Heat Exchanger and Tank: Free from defects in material and workmanship.
 - b. Warranty Coverage: **[Prorated Year 0 to 5 - 100 percent; Year 6 to 7 - 50 percent; Year 8 to 9 - 30 percent; Year 10 - 10 percent]** for <Insert number> years from date of Substantial Completion.
 - 3. Warranty Period for Wall-Hung Fire-Tube Condensing Boilers:
 - a. Heat Exchanger and Tank: Free from defects in material and workmanship.

- b. Warranty Coverage: **[Prorated Year 0 to 5 - 100 percent; Year 6 to 7 - 50 percent; Year 8 to 9 - 30 percent; Year 10 - 10 percent]**<Insert number> years from date of Substantial Completion.
- 4. Warranty Period for Floor-Mounted Water-Tube Condensing Boilers:
 - a. Heat Exchanger and Tank: Free from defects in material and workmanship.
 - b. Warranty Coverage: **[Prorated Year 0 to 5 - 100 percent; Year 6 to 7 - 50 percent; Year 8 to 9 - 30 percent; Year 10- 10 percent]**<Insert number> years from date of Substantial Completion.
- 5. Warranty Period for Wall Hung Water-Tube Condensing Boilers:
 - a. Heat Exchanger and Tank: Free from defects in material and workmanship.
 - b. Warranty Coverage: **[Prorated Year 0 to 5 - 100 percent; Year 6 to 7 - 50 percent; Year 8 to 9 - 30 percent; Year 10- 10 percent]**<Insert number> years from date of Substantial Completion.
- 6. Warranty Period for Water-Jacketed Condensing Boilers:
 - a. Heat Exchanger and Tank: Free from defects in material and workmanship.
 - b. Warranty Coverage: **[Prorated Year 0 to 5 - 100 percent; Year 6 to 7 - 50 percent; Year 8 to 9 - 30 percent; Year 10 - 10 percent]** for <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
- C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency in accordance with Table 6.8.1-6 and other requirements in Ch. 6 of ASHRAE/IES 90.1.
- D. ASHRAE 90.2 Compliance: Boilers shall have minimum efficiency in accordance with Ch. 6 of ASHRAE 90.2.
- E. DOE Compliance: Minimum efficiency shall comply with **[10 CFR 431, Subpart E, Appendix N][10 CFR 430, Subpart B, Appendix N]**.
- F. Mounting Base: **[For securing boiler to concrete base][For securing boiler to structural wall]**.
 - 1. Seismic Fabrication Requirements: Fabricate **[mounting base][and][wall support]** and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

2.2 PULSE-COMBUSTION, FIRE-TUBE CONDENSING BOILERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Fulton Boiler Works, Inc]**
 2. **[IBC Technologies; a Rheem brand]**
 3. **[RIELLO]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Fulton Boiler Works, Inc]**
 2. **[IBC Technologies; a Rheem brand]**
 3. **[RIELLO]**
 4. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated, -assembled, and -tested, pulse-combustion condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.
- D. Combustion Chamber: **[Type 316L stainless steel][Carbon steel]**.
- E. Heat Exchangers: **[Type 316L stainless steel][Carbon steel]**.
- F. Pressure Vessel: Carbon steel with welded heads and tube connections.
- G. Exhaust Decoupler: Fiberglass composite material in a corrosion-resistant steel box.
- H. Burner: **[Natural][Propane]** gas, self-aspirating and self-venting after initial start.
- I. Blower: Centrifugal fan to operate only during start of each burner sequence.
1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.
- J. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
- K. Ignition: Direct-spark ignition with transformer and 100 percent main-valve shutoff with electronic flame supervision.
- L. Casing:
1. Jacket: Sheet metal, with snap-in or interlocking closures.
 2. Control Compartment Enclosure: NEMA 250, Type 1A.
 3. Finish: **[Baked-enamel][Powder-coated][Stainless steel]** protective finish.
 4. Insulation: Minimum **2-inch- (50-mm-)** thick, mineral-fiber insulation surrounding heat exchanger.
 5. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.

- M. Mufflers: Carbon-steel intake muffler and stainless steel exhaust.
- N. Condensate Trap: Cast-iron body with stainless steel internal parts.
- O. Capacities and Characteristics:
 - 1. Design Water-Pressure Rating: **[15 psig (104 kPa)][150 psig (1035 kPa)]<Insert pressure rating>**.
 - 2. Safety Relief Valve Setting: **<Insert psig (kPa)>**.
 - 3. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 - 4. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
 - 5. Design Water Flow Rate: **<Insert gpm (L/s)>**.
 - 6. Design Pressure Drop: **<Insert psig (kPa)>**.
 - 7. Minimum Efficiency AFUE: **<Insert number>** percent.
 - 8. Minimum Thermal Efficiency: **<Insert number>** percent.
 - 9. Minimum Combustion Efficiency: **<Insert number>** percent.
 - 10. AGA Input: **<Insert MBh (kW)>**.
 - 11. Gas Input: **<Insert cfh (mL/s)>**.
 - 12. AGA Output Capacity: **<Insert MBh (kW)>**.
 - 13. DOE Output Capacity: **<Insert MBh (kW)>**.
 - 14. Equivalent Direct Radiation: **<Insert EDR (kW)>**.
 - 15. Electrical Characteristics:
 - a. Volts: **[115][208][230][460]<Insert number>** V.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: **[50][60]<Insert number>** Hz.
 - d. Full-Load Amperes: **<Insert number>** A.
 - e. Minimum Circuit Ampacity: **<Insert number>** A.
 - f. Maximum Overcurrent Protection: **<Insert number>** A.

2.3 FLOOR-MOUNTED, FORCED-DRAFT, FIRE-TUBE CONDENSING BOILERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[AERCO; A WATTS Brand]**
 - 2. **[Bosch Thermotechnology Corp.]**
 - 3. **[Cleaver-Brooks]**
 - 4. **[Fulton Boiler Works, Inc]**
 - 5. **[Heat Transfer Products, Inc]**
 - 6. **[IBC Technologies; a Rheem brand]**
 - 7. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
 - 8. **[Lochinvar, LLC]**
 - 9. **[Patterson-Kelley]**
 - 10. **[Raypak; a Rheem brand]**
 - 11. **[Weil-McLain]**
 - 12. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[AERCO; A WATTS Brand]**
 - 2. **[Bosch Thermotechnology Corp.]**
 - 3. **[Cleaver-Brooks]**

4. [Fulton Boiler Works, Inc]
 5. [Heat Transfer Products, Inc]
 6. [IBC Technologies; a Rheem brand]
 7. [Laars Heating Systems Company; a subsidiary of Bradford White Corporation]
 8. [Lochinvar, LLC]
 9. [Patterson-Kelley]
 10. [Raypak; a Rheem brand]
 11. [Weil-McLain]
 12. <Insert manufacturer's name>
- C. Description: Factory-fabricated, -assembled, and -tested, fire-tube, forced-draft, condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Units are to be for water-heating service only.
- D. Primary Heat Exchanger: Corrosion-resistant [Type 316 stainless steel][cast iron][or][aluminum].
- E. Secondary Heat Exchanger: Corrosion-resistant [Type 316 stainless steel][cast iron][or][aluminum].
- F. Combustion Chamber and Flue Pipes: Corrosion-resistant [stainless steel][or][aluminum].
- G. Pressure Vessel: Carbon steel with welded heads and tube connections.
- H. Burner: [Natural gas][Propane][Dual fuel (gas and propane)][Dual fuel (gas and No. 2 fuel oil)], forced draft.
- I. Blower: Centrifugal fan to operate during each burner-firing sequence and to prepurge and postpurge the combustion chamber.
1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.
- J. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
- K. Ignition: Direct-spark ignition or silicone carbide hot-surface ignition with 100 percent main-valve shutoff and electronic flame supervision.
- L. Casing:
 1. Jacket: [Sheet metal][Plastic], with snap-in or interlocking closures.
 2. Control Compartment Enclosures: NEMA 250, Type 1A.
 3. Finish: [Baked-enamel][Powder-coated][Stainless steel] protective finish.
 4. Insulation: Minimum 2-inch- (50-mm-) thick, [mineral-fiber][polyurethane-foam] insulation surrounding the heat exchanger.
 5. Combustion-Air Connections: Inlet and vent duct collars.
- M. Capacities and Characteristics:
 1. Heating Medium: Hot water.
 2. Design Water-Pressure Rating: [160 psig (1100 kPa)]<Insert value>.
 3. Safety Relief Valve Setting: <Insert psig (kPa)>.
 4. Entering-Water Temperature: <Insert deg F (deg C)>.

5. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
6. Design Water Flow Rate: **<Insert gpm (L/s)>**.
7. Minimum Water Flow Rate: **<Insert gpm (L/s)>**.
8. Design Pressure Drop: **<Insert psig (kPa)>**.
9. Minimum Efficiency AFUE: **<Insert number>** percent.
10. Minimum Thermal Efficiency: **<Insert number>** percent.
11. Minimum Combustion Efficiency: **<Insert number>** percent.
12. AGA Input: **<Insert MBh (kW)>**.
13. Gas Input: **<Insert cfh (mL/s)>**.
14. AGA Output Capacity: **<Insert MBh (kW)>**.
15. DOE Output Capacity: **<Insert MBh (kW)>**.
16. Equivalent Direct Radiation: **<Insert EDR (kW)>**.
17. Electrical Characteristics:
 - a. Volts: **[115][208][230][460]<Insert number>** V.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: **[50][60]<Insert number>** Hz.
 - d. Full-Load Amperes: **<Insert number>** A.
 - e. Minimum Circuit Ampacity: **<Insert number>** A.
 - f. Maximum Overcurrent Protection: **<Insert number>** A.

2.4 WALL-HUNG, FORCED-DRAFT, FIRE-TUBE CONDENSING BOILERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Heat Transfer Products, Inc]**
 2. **[IBC Technologies; a Rheem brand]**
 3. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
 4. **[Lochinvar, LLC]**
 5. **[Navien Inc.]**
 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Heat Transfer Products, Inc]**
 2. **[IBC Technologies; a Rheem brand]**
 3. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
 4. **[Lochinvar, LLC]**
 5. **[Navien Inc.]**
 6. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated, -assembled, and -tested, fire-tube, forced-draft, condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Units are to be for water-heating service only.
- D. Heat Exchanger: Corrosion-resistant **[Type 316 stainless steel]**.
- E. Fire Tubes: Corrosion-resistant **[Type 316 stainless steel][or][aluminum core]**.
- F. Combustion Chamber and Flue Pipes: Corrosion-resistant **[stainless steel][or][aluminum]**.

- G. Burner: **[Natural gas][Propane]**, forced draft.
- H. Blower: Centrifugal fan to operate during each burner-firing sequence and to prepurge and postpurge the combustion chamber.
1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.
- I. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
- J. Ignition: Direct-spark ignition or silicone carbide hot-surface ignition with 100 percent main-valve shutoff and electronic flame supervision.
- K. Integral Circulator: Cast-iron body and stainless steel impeller sized for minimum flow required in heat exchanger.
- L. Casing:
1. Jacket: **[Sheet metal][Plastic]**, with snap-in or interlocking closures.
 2. Control Compartment Enclosures: NEMA 250, Type 1A.
 3. Finish: **[Baked-enamel][Powder-coated][Stainless steel]** protective finish.
 4. Insulation: Minimum **2-inch- (50-mm-)** thick, **[mineral-fiber][polyurethane-foam]** insulation surrounding the heat exchanger.
 5. Combustion-Air Connections: Inlet and vent duct collars.
- M. Capacities and Characteristics:
1. Heating Medium: Hot water.
 2. Design Water-Pressure Rating: **[160 psig (1100 kPa)]<Insert value>**.
 3. Safety Relief Valve Setting: **<Insert psig (kPa)>**.
 4. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 5. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
 6. Design Water Flow Rate: **<Insert gpm (L/s)>**.
 7. Minimum Water Flow Rate: **<Insert gpm (L/s)>**.
 8. Design Pressure Drop: **<Insert psig (kPa)>**.
 9. Minimum Efficiency AFUE: **<Insert number>** percent.
 10. Minimum Thermal Efficiency: **<Insert number>** percent.
 11. Minimum Combustion Efficiency: **<Insert number>** percent.
 12. AGA Input: **<Insert MBh (kW)>**.
 13. Gas Input: **<Insert cfh (mL/s)>**.
 14. AGA Output Capacity: **<Insert MBh (kW)>**.
 15. DOE Output Capacity: **<Insert MBh (kW)>**.
 16. Equivalent Direct Radiation: **<Insert EDR (kW)>**.
 17. Electrical Characteristics:
 - a. Volts: **[115][208][230][460]<Insert number>** V.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: **[50][60]<Insert number>** Hz.
 - d. Full-Load Amperes: **<Insert number>** A.
 - e. Minimum Circuit Ampacity: **<Insert number>** A.
 - f. Maximum Overcurrent Protection: **<Insert number>** A.

2.5 FLOOR-MOUNTED, WATER-TUBE CONDENSING BOILERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Advanced Thermal Hydronics; a Mestek company]**
 2. **[AERCO; A WATTS Brand]**
 3. **[Bosch Thermotechnology Corp.]**
 4. **[Bryan Boilers; Bryan Steam LLC]**
 5. **[Cleaver-Brooks]**
 6. **[Embassy Industries, Inc.]**
 7. **[Gasmaster Industries Incorporated]**
 8. **[Heat Transfer Products, Inc]**
 9. **[Hydrotherm, Inc./Mestek, Inc.]**
 10. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
 11. **[Lochinvar, LLC]**
 12. **[Patterson-Kelley]**
 13. **[Raypak; a Rheem brand]**
 14. **[Smith Cast Iron Boilers]**
 15. **[Triangle Tube]**
 16. **[Viessmann Manufacturing Co. (US) Inc.]**
 17. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Advanced Thermal Hydronics; a Mestek company]**
 2. **[AERCO; A WATTS Brand]**
 3. **[Bosch Thermotechnology Corp.]**
 4. **[Bryan Boilers; Bryan Steam LLC]**
 5. **[Cleaver-Brooks]**
 6. **[Embassy Industries, Inc.]**
 7. **[Gasmaster Industries Incorporated]**
 8. **[Heat Transfer Products, Inc]**
 9. **[Hydrotherm, Inc./Mestek, Inc.]**
 10. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
 11. **[Lochinvar, LLC]**
 12. **[Patterson-Kelley]**
 13. **[Raypak; a Rheem brand]**
 14. **[Smith Cast Iron Boilers]**
 15. **[Triangle Tube]**
 16. **[Viessmann Manufacturing Co. (US) Inc.]**
 17. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated, -assembled, and -tested, water-tube, forced-draft, condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Units are to be for water-heating service only.
- D. Heat Exchanger: Stainless steel primary and secondary heat exchangers.
- E. Combustion Chamber: Stainless steel, sealed.
- F. Burner: **[Natural][Propane]** gas, forced draft drawing from gas-premixing valve.



- G. Blower: Centrifugal fan to operate during each burner-firing sequence and to prepurge and postpurge the combustion chamber.
1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.
- H. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
- I. Ignition: Direct-spark ignition or silicone carbide hot-surface ignition with 100 percent main-valve shutoff and electronic flame supervision.
- J. Integral Circulator: Cast-iron body and stainless steel impeller sized for minimum flow required in heat exchanger.
- K. Casing:
1. Jacket: Sheet metal, with snap-in or interlocking closures.
 2. Control Compartment Enclosures: NEMA 250, Type 1A.
 3. Finish: **[Baked-enamel][Powder-coated][Stainless steel]** protective finish.
 4. Insulation: Minimum **[1-inch- (25-mm-)][2-inch- (50-mm-)]** thick, mineral-fiber insulation surrounding the heat exchanger.
 5. Combustion-Air Connections: Inlet and vent duct collars.
- L. Capacities and Characteristics:
1. Heating Medium: Hot water.
 2. Design Water-Pressure Rating: **[160 psig (1100 kPa)]<Insert value>**.
 3. Safety Relief Valve Setting: **<Insert psig (kPa)>**.
 4. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 5. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
 6. Design Water Flow Rate: **<Insert gpm (L/s)>**.
 7. Minimum Water Flow Rate: **<Insert gpm (L/s)>**.
 8. Design Pressure Drop: **<Insert psig (kPa)>**.
 9. Fuel: **[Natural gas][Propane][Dual fuel (gas and propane)]**.
 10. Minimum Efficiency AFUE: **<Insert number>** percent.
 11. Minimum Thermal Efficiency: **<Insert number>** percent.
 12. Minimum Combustion Efficiency: **<Insert number>** percent.
 13. AGA Input: **<Insert MBh (kW)>**.
 14. Gas Input: **<Insert cfh (mL/s)>**.
 15. AGA Output Capacity: **<Insert MBh (kW)>**.
 16. DOE Output Capacity: **<Insert MBh (kW)>**.
 17. Electrical Characteristics:
 - a. Volts: **[115][208][230][460]<Insert number>** V.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: **[50][60]<Insert number>** Hz.
 - d. Full-Load Amperes: **<Insert number>** A.
 - e. Minimum Circuit Ampacity: **<Insert number>** A.
 - f. Maximum Overcurrent Protection: **<Insert number>** A.

2.6 WALL HUNG, WATER-TUBE CONDENSING BOILERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Embassy Industries, Inc.]**
 2. **[Heat Transfer Products, Inc]**
 3. **[Hydrotherm, Inc./Mestek, Inc.]**
 4. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
 5. **[Lochinvar, LLC]**
 6. **[Smith Cast Iron Boilers]**
 7. **[Triangle Tube]**
 8. **[Viessmann Manufacturing Co. (US) Inc.]**
 9. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Embassy Industries, Inc.]**
 2. **[Heat Transfer Products, Inc]**
 3. **[Hydrotherm, Inc./Mestek, Inc.]**
 4. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
 5. **[Lochinvar, LLC]**
 6. **[Smith Cast Iron Boilers]**
 7. **[Triangle Tube]**
 8. **[Viessmann Manufacturing Co. (US) Inc.]**
 9. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated, -assembled, and -tested, water-tube, forced-draft, condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.
- D. Heat Exchanger: Stainless steel primary and secondary heat exchangers.
- E. Combustion Chamber: Stainless steel, sealed.
- F. Burner: **[Natural][Propane]** gas, forced draft drawing from gas-premixing valve.
- G. Blower: Centrifugal fan to operate during each burner-firing sequence and to prepurge and postpurge the combustion chamber.
1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.
- H. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
- I. Ignition: Direct-spark ignition or silicone carbide hot-surface ignition with 100 percent main-valve shutoff and electronic flame supervision.
- J. Integral Circulator: Cast-iron body and stainless steel impeller sized for minimum flow required in heat exchanger.

K. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: **[Baked-enamel][Powder-coated][Stainless steel]** protective finish.
4. Insulation: Minimum **[1-inch- (25-mm-)][2-inch- (50-mm-)]** thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

L. Capacities and Characteristics:

1. Heating Medium: Hot water.
2. Design Water-Pressure Rating: **[160 psig (1100 kPa)]<Insert value>**.
3. Safety Relief Valve Setting: **<Insert psig (kPa)>**.
4. Entering-Water Temperature: **<Insert deg F (deg C)>**.
5. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
6. Design Water Flow Rate: **<Insert gpm (L/s)>**.
7. Minimum Water Flow Rate: **<Insert gpm (L/s)>**.
8. Design Pressure Drop: **<Insert psig (kPa)>**.
9. Fuel: **[Natural gas][Propane][Dual fuel (gas and propane)]**.
10. Minimum Efficiency AFUE: **<Insert number>** percent.
11. Minimum Thermal Efficiency: **<Insert number>** percent.
12. Minimum Combustion Efficiency: **<Insert number>** percent.
13. AGA Input: **<Insert MBh (kW)>**.
14. Gas Input: **<Insert cfh (mL/s)>**.
15. AGA Output Capacity: **<Insert MBh (kW)>**.
16. DOE Output Capacity: **<Insert MBh (kW)>**.
17. Electrical Characteristics:
 - a. Volts: **[115][208][230][460]<Insert number>** V.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: **[50][60]<Insert number>** Hz.
 - d. Full-Load Amperes: **<Insert number>** A.
 - e. Minimum Circuit Ampacity: **<Insert number>** A.
 - f. Maximum Overcurrent Protection: **<Insert number>** A.

2.7 WATER-JACKETED CONDENSING BOILERS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Bosch Thermotechnology Corp.]**
2. **[Heat Transfer Products, Inc]**
3. **[Hydrotherm, Inc./Mestek, Inc.]**
4. **[Lochinvar, LLC]**
5. **[RIELLO]**
6. **[Viessmann Manufacturing Co. (US) Inc.]**
7. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Bosch Thermotechnology Corp.]**

2. **[Heat Transfer Products, Inc]**
 3. **[Hydrotherm, Inc./Mestek, Inc.]**
 4. **[Lochinvar, LLC]**
 5. **[RIELLO]**
 6. **[Viessmann Manufacturing Co. (US) Inc.]**
 7. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated, -assembled, and -tested, water-jacketed condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; water supply, return, and condensate drain connections; and controls. Units are to be for water-heating service only.
- D. Heat Exchanger: Stainless steel primary and secondary heat exchangers.
- E. Burner: **[Natural][Propane]** modulating gas, forced draft; stainless steel cylinder burner.
- F. Blower: Centrifugal fan, forced draft. Include prepurge and postpurge of the combustion chamber.
1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.
- G. Gas Train: Combination gas valve with manual shutoff and pressure regulator. Include 100 percent safety shutoff with electronic flame supervision.
- H. Ignition: Electric-spark ignition or silicone carbide hot-surface ignition with 100 percent main-valve shutoff with electronic flame supervision.
- I. Casing:
1. Jacket: Sheet metal, with snap-in or interlocking closures.
 2. Control Compartment Enclosures: NEMA 250, Type 1A.
 3. Finish: Powder-coated protective finish.
 4. Insulation: Minimum **2-inch- (50-mm-)** thick, mineral-fiber insulation surrounding the heat exchanger.
 5. Combustion-Air Connections: Inlet and vent duct collars.
- J. Capacities and Characteristics:
1. Heating Medium: Hot water.
 2. Design Water-Pressure Rating: **[160 psig (207 kPa)]<Insert value>**.
 3. Safety Relief Valve Setting: **<Insert psig (kPa)>**.
 4. Maximum Design Temperature: **210 deg F (99 deg C)**.
 5. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 6. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
 7. Design Water Flow Rate: **<Insert gpm (L/s)>**.
 8. Design Pressure Drop: **<Insert psig (kPa)>**.
 9. Minimum Efficiency AFUE: **<Insert number>** percent.
 10. Minimum Thermal Efficiency: **<Insert number>** percent.
 11. Minimum Combustion Efficiency: **<Insert number>** percent.
 12. AGA Input: **<Insert MBh (kW)>**.
 13. Gas Input: **<Insert cfh (mL/s)>**.
 14. AGA Output Capacity: **<Insert MBh (kW)>**.
 15. DOE Output Capacity: **<Insert MBh (kW)>**.

16. Equivalent Direct Radiation: <Insert EDR (kW)>.
17. Electrical Characteristics:
 - a. Volts: [115][208][230][460]<Insert number> V.
 - b. Phase: [Single][Three].
 - c. Hertz: [50][60]<Insert number> Hz.
 - d. Full-Load Amperes: <Insert number> A.
 - e. Minimum Circuit Ampacity: <Insert number> A.
 - f. Maximum Overcurrent Protection: <Insert number> A.

2.8 TRIM - FOR HOT-WATER BOILERS

- A. Include devices sized to comply with [ASME B31.1][ASME B31.9].
- B. Aquastat Controllers: Operating[, firing rate,] and high limit with [manual][automatic] reset.
- C. Safety Relief Valve: ASME rated.
- D. Pressure and Temperature Gauge: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gauge. Gauges shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.
- E. High and low gas-pressure switches.
- F. Alarm bell with silence switch.
- G. Boiler Air Vent: [Automatic][Manual].
- H. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.
- I. Circulation Pump: Nonoverloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

2.9 CONTROLS

- A. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- B. Boiler operating controls shall include the following devices and features:
 1. Control transformer.
 2. Set-Point Adjust: All set points shall be adjustable.
 3. Electric, factory-fabricated and [factory-installed][field-installed] panel to [modulate burner][and][control burner-firing rate] to maintain space temperature in response to thermostat with heat anticipator located in heated space.
 - a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
 4. Electric, factory-fabricated and [factory-installed][field-installed] panel to control burner-firing rate, to reset supply-water temperature inversely with outside-air temperature. At [0 deg F (minus 17 deg C)]<Insert temperature> outside-air temperature, set supply-water temperature

at [140 deg F (60 deg C)]<Insert temperature>; at [60 deg F (15 deg C)]<Insert temperature> outside-air temperature, set supply-water temperature at [90 deg F (32 deg C)]<Insert temperature>.

- a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
- C. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
1. High Cutoff: [Manual][Automatic] reset stops burner if operating conditions rise above maximum boiler design temperature.
 2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be [manual][automatic]-reset type.
 3. Blocked Inlet Safety Switch: Manual-reset pressure switch [factory][field] mounted on boiler combustion-air inlet.
 4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
- D. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
1. Hardwired Points:
 - a. Monitoring: On/off status, [common trouble alarm][low-water-level alarm]<Insert monitoring>.
 - b. Control: On/off operation, [hot-water-supply temperature set-point adjustment]<Insert control>.
 2. A [BACnet][Metasys][Lonworks]<Insert type> communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. All monitoring and control features, which are available at the local boiler control panel, shall also be available at the remote operator workstation through the building automation system.

2.10 ELECTRICAL POWER

- A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are shown on Drawings and specified in electrical Sections.
- B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
 1. House in NEMA 250, [Type 1]<Insert type> enclosure.
 2. Wiring shall be numbered and color coded to match wiring diagram.
 3. Install factory wiring outside of an enclosure in a [metal]raceway.
 4. Field power interface shall be to [wire lugs][fused disconnect switch][nonfused disconnect switch][circuit breaker].
 5. Provide branch power circuit to each motor and to controls[with a disconnect switch or circuit breaker].
 6. Provide each motor with overcurrent protection.

2.11 VENTING KITS

- A. Kit: Complete system, ASTM A959, Type 29-4C stainless steel pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
- B. Combustion-Air Intake: Complete system, stainless steel pipe, vent terminal with screen, inlet air coupling, and sealant.

2.12 CONDENSATE-NEUTRALIZATION UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[Neutra-Safe Corporation]**
 - 2. **[SFA Saniflo USA]**
 - 3. **[Skidmore Pump]**
 - 4. **[Wessels Company]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Neutra-Safe Corporation]**
 - 2. **[SFA Saniflo USA]**
 - 3. **[Skidmore Pump]**
 - 4. **[Wessels Company]**
 - 5. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated and -assembled condensate-neutralizing **[capsule][tank]** assembly of corrosion-resistant plastic material with threaded or flanged inlet and outlet pipe connections. Device functions to prevent acidic condensate from damaging grain system. It is to be piped to receive acidic condensate discharged from condensing boiler and neutralize it by chemical reaction with replaceable neutralizing agent. Neutralized condensate is then piped to suitable drain.
- D. **[Capsule][Tank]** features:
 - 1. All corrosion-resistant material.
 - 2. Suitable for use on all natural gas and propane boilers.
 - 3. Includes initial charge of neutralizing agent.
 - 4. Neutralizing agent to be easily replaceable when exhausted.
 - 5. Inlet and outlet pipe connections.
- E. Capsule Configuration:
 - 1. Low-profile design for applications where boiler condensate drain is close to the floor.
 - 2. Easily removed and opened for neutralizing agent replacement.
 - 3. Multiple units may be used for larger capacity.
- F. Tank Configuration:
 - 1. Utilized where boiler is elevated or where tank is installed in a pit with tank top flush with floor.
 - 2. Top easily removed for neutralizing agent replacement.
 - 3. Internal baffles to channel flow for complete neutralization.

4. Integral bypass to prevent condensate backflow into appliance.
5. Multiple units may be used for larger capacity.

2.13 SOURCE QUALITY CONTROL

- A. UL Compliance: Test gas-fired boilers having input of more than **400,000 Btu/h (117 kW)** for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- B. UL Compliance, Oil-Fired: Test oil-fired boilers for compliance with UL 726. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- C. UL Compliance, Gas-Fired: Test gas-fired boilers for compliance with UL 2764. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- D. CSA Compliance: Test boilers for compliance with ANSI Z21.13-2017/CSA 4.9.
- E. Performance Testing: Test and label boilers for efficiency to comply with AHRI 1500.
- F. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- G. Test and inspect factory-assembled boilers, before shipping, in accordance with 2017 ASME Boiler and Pressure Vessel Code. Factory test boilers for safety and functionality; fill boiler with water, and fire throughout firing range, to prove operation of all safety components.
- H. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.
 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical spaces for suitable conditions where boilers will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

- A. Equipment Mounting:
 1. Install floor-mounted boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place

- Concrete."
- 2. Install wall-hung boilers where indicated on Drawings using suitable hangers. Comply with manufacturer's mounting instructions.
- 3. Comply with requirements for vibration isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- 4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

- B. Install gas-fired boilers according to NFPA 54.
- C. Assemble and install boiler trim.
- D. Install electrical devices furnished with boiler but not specified to be factory mounted.
- E. Install control wiring to field-mounted electrical devices.

3.3 PIPING CONNECTIONS

- A. Comply with requirements for hydronic piping specified in Section 232113 "Hydronic Piping."
- B. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."
- C. Drawings indicate general arrangement of piping, fittings, and specialties.
- D. When installing piping adjacent to boiler, allow space for service and maintenance of condensing boilers. Arrange piping for easy removal of condensing boilers.
- E. Install condensate drain piping to condensate-neutralization unit and from neutralization unit to nearest floor drain. Piping shall be at least full size of connection. Install piping with a minimum of 2 percent downward slope in direction of flow.
- F. Install condensate piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Install piping with a minimum of 2 percent downward slope in direction of flow.
- G. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.
- H. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve, and union or flange at each connection.
- I. Install piping from safety relief valves to nearest floor drain.

3.4 DUCT CONNECTIONS

- A. Boiler Venting:
 - 1. Install flue-venting kit and combustion-air intake.
 - 2. Field fabricate and install boiler vent and combustion-air intake.
 - 3. Utilize vent and intake duct material, size, and configuration as indicated in boiler manufacturer's instructions and to comply with UL 1738.

4. Connect boiler vent full size to boiler connections.
5. Comply with requirements in Section 235123 "Gas Vents."
6. Comply with all boiler manufacturer's installation instructions.

3.5 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert size> high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.
 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert size> high.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency, Owner: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency, Contractor: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections[**with the assistance of a factory-authorized service representative**]:
- E. Tests and Inspections:
 1. Perform installation and startup checks in accordance with manufacturer's written instructions.
 2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel



- ratio and combustion.
- 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
 - b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- F. Boiler will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.
- H. Occupancy Adjustments: When requested within **[12 months of date of Substantial Completion]<Insert time period>**, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training." **[Video record the training sessions and provide electronic copy to Owner.]**
 - 1. Instructor shall be factory trained and certified.
 - 2. Provide not less than **[two]<Insert number>** hours of training.
 - 3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
 - 4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 - 5. Obtain Owner sign-off that training is complete.
 - 6. Owner training shall be held at Project site.

END OF SECTION 23 52 16 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 52 16 13	23 52 16 00	Condensing Boilers
23 52 16 16	23 52 16 00	Condensing Boilers
23 52 16 19	23 52 16 00	Condensing Boilers
23 52 16 23	23 52 16 00	Condensing Boilers



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 52 23 00 - CAST-IRON BOILERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Cast-iron boilers, trim, and accessories for generating hot water and steam.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
1. Product Data: For energy performance.
- C. Shop Drawings: For boilers, boiler trim, and accessories.
1. Include plans, elevations, sections, and **[mounting][attachment]** details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
- D. Delegated Design Submittals: For each boiler.
1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for boiler, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- B. Source quality-control reports.
- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.
- E. Product Test Reports:
 - 1. CSA B51 pressure vessel Canadian Registration Number (CRN).
 - 2. Startup service reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For boilers, components, and accessories to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace controls and heat exchangers of boilers that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Controls: **[Two]<Insert number>** years from date of Substantial Completion.
 - 2. Warranty Period for Heat Exchangers: **[Five][10][20]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.
- C. ASHRAE/IES 90.1 Compliance: Boilers are to have minimum efficiency in accordance with "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- D. DOE Compliance: Minimum efficiency is to comply with 10 CFR 430, Subpart B, Appendix N.
- E. I=B=R Compliance: Boilers are to be tested and rated in accordance with AHRI's "Rating Procedure for Heating Boilers" and "Testing Standard for Commercial Boilers," with I=B=R emblem on a nameplate affixed to boiler.
- F. UL Compliance: Test boilers for compliance with **[UL 726][UL 726 and UL 795][UL 795]**. Boilers are to be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- G. CSA Compliance: Test boilers for compliance with CSA B51.
- H. Mounting Frame: Steel rails used to mount assembled boiler package on concrete base.

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

2.2 CAST-IRON BOILERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Burnham Hydronics]**
2. **[Crown Boiler Co]**
3. **[Hydrotherm, Inc./Mestek, Inc.]**
4. **[Lennox]**
5. **[Peerless Boilers; PB Heat LLC]**
6. **[Slant/Fin Corp]**
7. **[Smith Cast Iron Boilers]**
8. **[Viessmann Manufacturing Co. (US) Inc.]**
9. **[Weil-McLain]**
10. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Burnham Hydronics]**
2. **[Crown Boiler Co]**
3. **[Hydrotherm, Inc./Mestek, Inc.]**
4. **[Lennox]**
5. **[Peerless Boilers; PB Heat LLC]**
6. **[Slant/Fin Corp]**
7. **[Smith Cast Iron Boilers]**
8. **[Viessmann Manufacturing Co. (US) Inc.]**
9. **[Weil-McLain]**
10. **<Insert manufacturer's name>**

- C. Description: Factory fabricated and **[field]**assembled.

1. Cast-iron sections are to be sealed pressure tight and held together with tie rods **[set on an insulated steel base]**, including insulated jacket and flue-gas vent connection.
2. Ship cast-iron sections disassembled with all materials and equipment, including seals, tie rods, and insulated jacket and flue-gas vent connection for field assembly.

- D. Cast-Iron Section Design:

1. Configuration: Wet **[base][back][leg]**.
2. Number of Passes: **[Single][Multiple]**.
3. Sectional Joints: High-temperature sealant to seal flue-gas passages not in contact with heating medium, **[tapered cast-iron push nipples,][O-ring gaskets,][fiber roping,]** and held together with tie rods.
4. Drain and blowdown tappings.
5. Return injection tube to equalize water flow to all sections.
6. Crown inspection tappings with brass plugs.
7. Built-in air separator.



- E. Combustion Chamber: Equipped with **[ceramic-fiber target wall][refractory][insulation][and]** flame observation ports, front and back.
- F. Casing:
 - 1. Jacket: **[Galvanized sheet][Sheet]** metal, with snap-in or interlocking closures and **[baked-enamel][powder-coated]** protective finish.
 - 2. Insulation: Minimum **[1-inch- (25-mm-)][2-inch- (50-mm-)]** thick, mineral-fiber insulation surrounding the heat exchanger.
 - 3. Combustion Chamber Access: Refractory lined, hinged, front.
 - 4. Access: For cleaning between cast-iron sections.
 - 5. Draft Hood: Flue canopy and **[top][rear]** flue connection are to be constructed of **[aluminized][stainless]** steel containing adjustable outlet damper assembly.
 - 6. Insulated base constructed of aluminized steel to permit boiler to be installed on combustible floor.
 - 7. Control Cabinet: Sheet metal casing covers all controls, gas train, and burner.
- G. Draft Diverter: **[Steel assembly integral with boiler casing][Separate galvanized-steel assembly]**.

2.3 ATMOSPHERIC-GAS BURNER

- A. Burner Tubes and Orifices: **[Stainless steel][Cast iron]**, for **[natural][propane]** gas.
- B. Gas Train for Commercial Boilers: Control devices and **[full-modulation][on-off][low-high-low]** control sequence are to comply with requirements in **[ASME CSD-1][FM Global][IRI][UL]**.
- C. Gas Train for Residential Boilers: Combination-gas valve with manual shutoff, pressure regulator, and pilot adjustment.
- D. Pilot: **[Standing][Intermittent-electric-spark]** pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

2.4 SEALED-COMBUSTION BURNER

- A. Burner Tubes and Orifices: **[Stainless steel][Cast iron]**, for **[natural][propane]** gas.
- B. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor, with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - 1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- C. Gas Train: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
- D. Pilot: **[Standing][Intermittent-electric-spark]** pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

2.5 FORCED-DRAFT BURNER

- A. Burner: Welded construction with multivane, stainless steel, flame-retention diffuser for **[natural][propane]** gas.
- B. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor, with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - 1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- C. Gas Train: Control devices and **[modulating][on-off][low-high-low]** control sequence are to comply with requirements in **[ASME CSD-1][FM Global][IRI][UL]**.
- D. Pilot: **[Intermittent][Interrupted]**-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
- E. Flue-Gas Recirculation: Burner connections are to be equipped for recirculating flue gas.
 - 1. Maximum Oxides of Nitrogen Emissions: **[20][30]<Insert number>** ppm.

2.6 OIL BURNER

- A. Burner: Welded construction with multivane, stainless steel, flame-retention diffuser for fuel oil.
- B. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor, with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - 1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- C. Oil Supply: Control devices and **[modulating][on-off][low-high-low]** control sequence are to comply with requirements in **[ASME CSD-1][FM Global][IRI][UL]**.
 - 1. Oil Pump: Two-stage, gear-type oil pump **[integral to and directly driven by blower]** capable of producing **300-psig (2070-kPa)** discharge pressure and **15-inch Hg (50.7-kPa)** vacuum.
 - 2. Oil Piping Specialties:
 - a. Suction-line, manual gate valve.
 - b. Removable-mesh oil strainer.
 - c. **0- to 30-inch Hg (0- to 101.3-kPa)** vacuum; **0- to 30-psig (0- to 207-kPa)** vacuum-pressure gage.
 - d. **0- to 300-psig (0- to 2070-kPa)** oil-nozzle pressure gage.
 - e. Nozzle-line, solenoid-safety-shutoff oil valve.
- D. Pilot: **[Intermittent][Interrupted]**-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid using **[cadmium sulfide][UV scanner]** flame-safety control.

E. Flue-Gas Recirculation: Burner connections are to be equipped for recirculating flue gas.

1. Maximum Oxides of Nitrogen Emissions: [20][30]<Insert number> ppm.

2.7 COMBINATION GAS AND OIL BURNER

A. Burner: Welded construction with multivane, stainless steel, flame-retention diffuser for fuel oil and [natural][propane] gas.

B. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor, with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

C. Oil Supply: Control devices and [modulating][on-off][low-high-low] control sequence are to comply with requirements in [ASME CSD-1][FM Global][IRI][UL].

1. Oil Pump: Two-stage, gear-type oil pump[integral to and directly driven by blower] capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.

2. Oil Piping Specialties:

a. Suction-line, manual, gate valve.

b. Removable-mesh oil strainer.

c. 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.

d. 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.

e. Nozzle-line, solenoid-safety-shutoff oil valve.

D. Gas Train: Control devices and [modulating][on-off][low-high-low] control sequence are to comply with requirements in [ASME CSD-1][FM Global][IRI][UL].

E. Gas Pilot: [Intermittent][Interrupted]-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

F. Oil Pilot: [Intermittent][Interrupted]-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with [cadmium sulfide][UV scanner] flame-safety control.

G. Flue-Gas Recirculation: Burner connections are to be equipped for recirculating flue gas.

1. Maximum Oxides of Nitrogen Emissions: [20][30]<Insert number> ppm.

2.8 TRIM FOR HOT-WATER BOILERS

A. Include devices sized to comply with ASME B31.9.

B. Aquastat Controllers: Operating[, firing rate,] and high limit.

C. Safety Relief Valve: ASME rated.

- D. Pressure and Temperature Gage: Minimum **3-1/2-inch- (89-mm-)** diameter, combination water-pressure and -temperature gage. Gages are to have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.
- E. Boiler Air Vent: **[Automatic][Manual]**.
- F. Drain Valve: Minimum **NPS 3/4 (DN 20)** hose-end gate valve.
- G. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of cast-iron sections and sealed with fiber gasket.
 - 1. Tappings NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1 for pipe threads.
 - 2. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges, and in accordance with ASME B16.24 for copper and copper-alloy flanges.

2.9 TRIM FOR STEAM BOILERS

- A. Include devices sized to comply with ASME B31.9.
- B. Pressure Controllers: Operating[, **firing rate**,] and high limit.
- C. Safety Relief Valve:
 - 1. Size and Capacity: As required for equipment in accordance with 2010 ASME Boiler and Pressure Vessel Code.
 - 2. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
 - a. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
- D. Pressure Gage: Minimum **3-1/2-inch (89-mm)** diameter. Gage is to have normal operating pressure about 50 percent of full range.
- E. Water Column: Minimum **12-inch (300-mm)** glass gage with shutoff cocks.
- F. Drain Valves: Minimum **NPS 3/4 (DN 20)** or nozzle size with hose-end connection.
- G. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle.
- H. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, are to be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size as or larger than nozzle. Valves larger than **NPS 2 (DN 50)** have rising stem.
- I. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
- J. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of cast-iron sections and sealed with fiber gasket.
 - 1. Tappings NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1 for pipe

threads.

2. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges, and in accordance with ASME B16.24 for copper and copper-alloy flanges.

2.10 CONTROLS

- A. See Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- B. Boiler operating controls include the following devices and features:
 1. Control transformer.
 2. Set-Point Adjust: Set points are to be adjustable.
 3. Operating Pressure Control: Factory wired and mounted to cycle burner.
 4. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.
 - a. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
 - 1) Include automatic, alternating-firing sequence for multiple boilers to provide equal runtime for boilers.
 - b. Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At [0 deg F (minus 17 deg C)]<Insert temperature> outside-air temperature, set supply-water temperature at [200 deg F (93 deg C)]<Insert temperature>; at [60 deg F (15 deg C)]<Insert temperature> outside-air temperature, set supply-water temperature at [140 deg F (60 deg C)]<Insert temperature>.
 - 1) Include automatic, alternating-firing sequence for multiple boilers to provide equal runtime for boilers.
 - c. Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
 - 1) Include automatic, alternating-firing sequence for multiple boilers to provide equal runtime for boilers.
- C. Safety Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
 1. High Cutoff: [Manual][Automatic] reset stops burner if operating conditions rise above maximum boiler design [temperature][pressure].
 2. Low-Water Cutoff Switch: [Electronic][Float and electronic] probe prevents burner operation on low water. Cutoff switch is to be [manual][automatic]-reset type.
 3. Blocked Vent Safety Switch: Manual-reset switch factory mounted on draft diverter.
 4. Rollout Safety Switch: Factory mounted on boiler combustion chamber.
 5. Audible Alarm: Factory mounted on control panel with silence switch; alarm sounds for above conditions.
- D. Building Management System Interface: Factory install hardware and software to enable building management system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:
 - a. Monitoring: On/off status, [common trouble alarm][low-water-level alarm]<Insert monitoring>.
 - b. Control: On/off operation, [hot-water-supply temperature set-point adjustment][steam pressure adjustment]<Insert control>.
2. A communication interface with building management system is to enable building management system operator to remotely control and monitor the boiler from an operator workstation. Control features available and monitoring points displayed, locally at boiler control panel is to be available through building management system.

2.11 ELECTRICAL POWER

- A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.
- B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary provide a single-point field power connection to boiler.
 1. House in NEMA 250, Type [1]<Insert type> enclosure.
 2. Wiring is to be numbered and color coded to match wiring diagram.
 3. Install factory wiring outside of an enclosure in a [metal]raceway.
 4. Field power interface is to be to [wire lugs][fused disconnect switch][nonfused disconnect switch][circuit breaker].
 5. Provide branch power circuit to each motor and to controls[with disconnect switch or circuit breaker].
 6. Provide each motor with overcurrent protection.

2.12 CAPACITIES AND CHARACTERISTICS

- A. Hot-Water Heating:
 1. Design Water-Pressure Rating: [30 psig (207 kPa)][50 psig (345 kPa)][80 psig (550 kPa)]<Insert pressure rating>.
 2. Safety Relief Valve Setting: <Insert psig (kPa)>.
 3. Entering-Water Temperature: <Insert deg F (deg C)>.
 4. Leaving-Water Temperature: <Insert deg F (deg C)>.
 5. Design Water Flow Rate: <Insert gpm (L/s)>.
 6. Design Pressure Drop: <Insert psig (kPa)>.
- B. Steam Heating:
 1. Design Steam-Pressure Rating: [Steam, 15 psig (104 kPa)]<Insert pressure rating>.
 2. Safety Relief Valve Setting: <Insert psig (kPa)>.
 3. Steam Operating Pressure: <Insert psig (kPa)>.
 4. Steam Flow Rate: <Insert lb/h (kg/s)>.
- C. Minimum Efficiency AFUE: <Insert number> percent.
- D. Minimum Thermal Efficiency: <Insert number> percent.
- E. Minimum Combustion Efficiency: <Insert number> percent.

- F. Number of Passes: **[One][Two]<Insert number>**.
- G. Input Rating Method:
1. AGA Input: **<Insert MBh (kW)>**.
 2. I=B=R Input: **<Insert MBh (kW)>**.
 3. Gas Input: **<Insert cfh (mL/s)>**.
 4. Oil Input: **<Insert gph (mL/s)>**.
- H. Output Capacity
1. AGA Output Capacity: **<Insert MBh (kW)>**.
 2. DOE Output Capacity: **<Insert MBh (kW)>**.
 3. Net I=B=R Output Capacity: **<Insert MBh (kW)>**.
 4. Gross I=B=R Output Capacity: **<Insert MBh (kW)>**.
 5. Equivalent Direct Radiation: **<Insert EDR (W)>**.
- I. Tankless Water Heater:
1. Design Water Flow: **<Insert gpm (L/s)>**.
 2. Design Pressure Drop: **<Insert psig (kPa)>**.
 3. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 4. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
- J. Blower:
1. Motor Horsepower: **<Insert number> hp**.
 2. RPM: **<Insert number>**.
- K. Electrical Characteristics:
1. Volts: **[115][208][230][460]<Insert number> V**.
 2. Phase: **[Single][Three]**.
 3. Hertz: **[50][60]<Insert number> Hz**.
 4. Full-Load Amperes: **<Insert number> A**.
 5. Minimum Circuit Ampacity: **<Insert number> A**.
 6. Maximum Overcurrent Protection: **<Insert number> A**.

2.13 SOURCE QUALITY CONTROL

- A. Test and inspect factory-assembled boilers, before shipping, in accordance with **[2010 ASME Boiler and Pressure Vessel Code][CSA B51]**.
- B. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.
 - 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical spaces for suitable conditions where boilers will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF CAST-IRON BOILERS

- A. Equipment Mounting:
 - 1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Install gas-fired boilers in accordance with NFPA 54.
- C. Install oil-fired boilers in accordance with NFPA 31.
- D. Assemble boiler sections in sequence and seal between each section.
- E. Assemble and install boiler trim.
- F. Install electrical devices furnished with boiler but not specified to be factory mounted.
- G. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in [**Section 232113 "Hydronic Piping"**][and][**Section 232213 "Steam and Condensate Heating Piping."**] Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to boiler to allow service and maintenance.
- C. Connect gas piping to boiler gas-train inlet with union. Piping is to be at least full size of gas-train connection. Provide a reducer if required.
- D. Connect oil piping full size to burner inlet with shutoff valve and union.
- E. Connect hot-water piping to supply- and return-boiler tapplings with shutoff valve and union or flange at

each connection.

- F. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.
- G. Install piping from safety relief valves to nearest floor drain.
- H. Install piping from safety valves to drip-pan elbow and to nearest floor drain.
- I. Install piping from equipment drain connection to nearest floor drain. Piping is to be at least full size of connection. Provide an isolation valve if required.
- J. Connect breeching full size to boiler outlet. Comply with requirements in Section 235116 "Fabricated Breechings and Accessories" for venting materials.
- K. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Section 235123 "Gas Vents" for recirculation duct materials.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Perform installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
 - b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and **[water temperature][steam pressure]**.
 - c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Performance Tests:
 - 1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - 2. Boilers are to comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
 - 3. Perform field performance tests to determine capacity and efficiency of boilers.
 - a. For dual-fuel boilers, perform tests for each fuel.

- b. Test for full capacity.
 - c. Test for boiler efficiency at [low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20]<Insert range> percent of full capacity. Determine efficiency at each test point.
 - 4. Repeat tests until results comply with requirements indicated.
 - 5. Provide analysis equipment required to determine performance.
 - 6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
 - 7. Notify Architect in advance of test dates.
 - 8. Document test results in a report and submit to Architect.
- F. Boiler will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within [12 months]<Insert time period> of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A. [Engage a factory-authorized service representative to train][Train] Owner's maintenance personnel to adjust, operate, and maintain boilers. See Section 017900 "Demonstration and Training."

END OF SECTION 23 52 23 00



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 52 33 00 - WATER-TUBE BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Finned water-tube boilers.
2. Steel or flexible water-tube boilers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product, include the following:

1. Construction details, material descriptions, dimensions, and weights of individual components, profiles, and finishes for boilers.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.
3. Predicted boiler efficiency while operating at design capacity and at varying part loads with basis indicated.
4. Predicted emissions levels while operating at design capacity and at varying part loads with basis indicated. Indicate operation that produces worst-case emissions.
5. Technical data for refractory and insulation, including temperature rating, thermal performance, attachment, and arrangement.
6. Calculations showing predicted surface temperature of boiler jacket with basis indicated.
7. Force and moment capacity of each piping and flue connection.
8. Dimensioned location of low, high, and normal water level, showing operating set point and each alarm set point.
9. Temperature and pressure rating, size, and materials of construction for boiler trim components, including piping, fittings, flanges, unions, and valves. Provide valve manufacturer's product data for each valve furnished. For safety valves, include trip and reset settings and flow capacity.
10. Manufacturer's product data showing size, scale range, and accuracy of thermometers and pressure gages.
11. Pressure rating, size, and materials of construction for boiler fuel train components, including piping, fittings, flanges, unions, switches, and valves. Provide manufacturer's product data for each valve and switch furnished.
12. Detailed information of controls, including product data with technical performance, operating characteristics, and sequence of operation.
13. Product data for each motor, including performance, operating characteristics, and materials of construction.

B. Sustainable Design Submittals:

1. Product Data: For energy performance.

C. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Design calculations and base details, signed and sealed by a qualified professional engineer.



- a. Design Calculations: Calculate requirements for selecting [**vibration isolators and**] seismic restraints and for designing bases.
 - b. Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring. Differentiate between factory and field installation.
 5. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan and elevation views, drawn to **<Insert scale>** scale, indicating equipment manufacturers' service clearances, structure and base attachment, piping, power, controls, and flues. Each view shows a screened background with the following:
 1. Column grids, beams, columns, and concrete housekeeping pads.
 2. Room layout with walls, floors, and roofs, including each room name and number.
 3. Equipment and products of other trades that are located in vicinity of boilers and are part of final installation, such as lighting, fire-suppression systems, and plumbing systems.
- B. Seismic Qualification Certificates: For boilers, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Installation instructions.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranty: For special warranty.
- G. Other Informational Submittals:
 1. ASME "A" Stamp Certification and Report: Submit "A" stamp certificate of authorization as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
 2. Startup service reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For boilers, components, and accessories to include in emergency, operation, and maintenance manuals.
- B. Spare Parts List: Recommended spare parts list with quantity for each.

- C. Touch-up Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.
- D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Tool kit to include the following:
 - 1. A tool kit specially designed by boiler manufacturer for use in servicing boiler(s) furnished.
 - 2. Special tools required to service boiler components not readily available to Owner service personnel in performing routine maintenance.
 - 3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Boiler Tool Kit." Text size shall be at least **1 inch (25 mm)** high.
 - 4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least **0.5 inch (13 mm)** high.
- B. Touch-up Paint: **[32-oz. (1-L)]<Insert volume>** container of paint used for finish coat. Label on outside of container shall have a detailed description of paint to allow for procurement of a matching paint in the future.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Ship boilers from the factory free of water. Drain water and blow dry with compressed air if required to remove all water before shipping.
- B. Cover and protect flue, electrical controls, and piping connections before shipping. Protect and seal openings and connections with blinds, caps, plugs, and other materials during delivery, storage, and handling.
- C. Protect boiler components with removable temporary enclosures to prevent damage during shipping, storage, and installation.
- D. Package boiler for export shipping in totally enclosed **[bagging][crate][crate with bagging]**.

1.7 WARRANTY

- A. Special Warranty:
 - 1. Manufacturer agrees to repair or replace heat exchangers damaged by thermal shock and vent dampers of boilers that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Heat Exchangers: **[20]<Insert number>** years from date of Substantial Completion.
 - b. Warranty Period for Vent Dampers: **[Five]<Insert number>** years from date of Substantial Completion.
 - 2. Manufacturer agrees to repair or replace drums, tubes, headers, cabinets, atmospheric gas burners, and pressure vessels of boilers that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Drums, Tubes, Headers, Cabinets, and Atmospheric Gas Burner:

- [Five]<Insert number> years from date of Substantial Completion, pro rata.
- b. Warranty Period for Pressure Vessel: [20]<Insert number> years from date of Substantial Completion, for thermal shock.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fuel-to-steam and fuel-to-water efficiency indicated is to be based on the following:
1. Efficiency Testing Method:
 - a. BTS-2000.
 - b. ASME Performance Test Code (PTC) 4, [Input-Output][Heat Loss] method.
 - c. <Insert test requirement>.
 2. Test Operating Conditions:
 - a. Ambient Temperature: <Insert temperature>.
 - b. Ambient Relative Humidity: <Insert relative humidity>.
 - c. Percent Excess Air in Exhaust Flue Gas: [15]<Insert number>.
 - d. Fuel Heating Value: <Insert value>.
- B. Gas-Fired Boiler Emissions: Not to exceed allowable ambient-air quality standards in governing jurisdiction and indicated values.
1. Carbon Monoxide:
 - a. [50]<Insert number> parts per million at any point from 100 percent to [50]<Insert number> percent fire.
 - b. [150]<Insert number> parts per million at any point below [50]<Insert number> percent fire.
 2. Nitrogen Compounds: [30][20][10]<Insert number> parts per million (dry volume basis and corrected to [3]<Insert number> percent oxygen) at any point from 100 percent to low fire.
 3. Sulfur Compounds: [One]<Insert number> part per million (dry volume basis and corrected to [3]<Insert number> percent oxygen) at any point from 100 percent to low fire.
 4. Hydrocarbon and Volatile Organic Compounds: [10]<Insert number> parts per million (dry volume basis and corrected to [3]<Insert number> percent oxygen) at any point from 100 percent to low fire.
 5. Particulate Matter: [0.01 lb/MMBtu]<Insert value>.
 6. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.
- C. Oil-Fired Boiler Emissions: Not to exceed allowable ambient-air quality standards in governing jurisdiction and indicated values.
1. Carbon Monoxide:
 - a. [50]<Insert number> parts per million at any point from 100 percent to [50]<Insert number> percent fire.
 - b. [150]<Insert number> parts per million at any point below [50]<Insert number> percent fire.

2. Nitrogen Compounds: [30][20][10]<Insert number> parts per million (dry volume basis and corrected to [3]<Insert number> percent oxygen) at any point from 100 percent to low fire.
 3. Sulfur Compounds: [One]<Insert number> part per million (dry volume basis and corrected to [3]<Insert number> percent oxygen) at any point from 100 percent to low fire.
 4. Hydrocarbon and Volatile Organic Compounds: [10]<Insert number> parts per million (dry volume basis and corrected to [3]<Insert number> percent oxygen) at any point from 100 percent to low fire.
 5. Particulate Matter: [0.01 lb/MMBtu]<Insert value>.
 6. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.
- D. Multiple Boiler Operation: Equip individual boilers in multiple boiler applications with integral controls to provide multiple boiler operation for optimum system performance, energy efficiency, and the following:
1. Equalize runtime of boilers in service.
 2. Operate multiple boilers hot to minimize disruption of service in the event of single boiler failure.
 3. Configure controls so any boiler can be taken out of service with power disconnected and not impact multiple boiler operation.
 4. <Insert requirement>.
- E. Seismic Performance: Boiler shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7]<Insert requirement>.
1. The term "withstand" means "the boiler will remain in place without separation of any parts when subjected to the seismic forces specified[**and the boiler will be fully operational after the seismic event**]."
 2. Component Importance Factor: [1.5][1.0].
 3. <Insert requirements for Component Amplification Factor and Component Response Modification Factor>.
- F. Sound: Boiler sound level, measured according to parameters defined in ABMA publication "Boiler 304 Measurement of Sound from Steam Generators" shall not exceed <Insert number> dBA.
- G. Steam Quality: [99][99.5]<Insert number> percent dry[**and saturated**].
- H. Operation Following Loss of Normal Power:
1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to back-up power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a back-up power source or through normal power if restored before back-up power is brought online.
 2. Refer to Drawings for equipment served by back-up power systems.
 3. Provide means and methods required to satisfy requirement even if not explicitly indicated.
- I. Outdoor Installations:
1. Boiler shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a [25]<Insert number> -year period, with minimal degradation due to exposure to outdoor ambient conditions.
 2. Boilers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past [30]<Insert number> -year period. Provide as part of boiler package, products, such as combustion-air pre-heaters and other means and methods required.



- J. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- K. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.
- L. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- M. DOE Compliance: Minimum efficiency for boilers with capacity of **300,000 Btu/h (87.9 kW)** shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."
- N. UL Compliance: Test boilers for compliance with **[UL 726][UL 726 and UL 795][UL 795]**. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

2.2 FINNED WATER-TUBE BOILERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[A. O. Smith Corporation]**
 - 2. **[Ajax Boiler Inc]**
 - 3. **[Allied Engineering Co.]**
 - 4. **[Green Boiler Technologies]**
 - 5. **[Harsco Industrial, Patterson-Kelley]**
 - 6. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
 - 7. **[Lochinvar, LLC]**
 - 8. **[Precision Boilers]**
 - 9. **[Raypak; a Rheem brand]**
 - 10. **[RBI]**
 - 11. **[RECO USA]**
 - 12. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[A. O. Smith Corporation]**
 - 2. **[Ajax Boiler Inc]**
 - 3. **[Allied Engineering Co.]**
 - 4. **[Green Boiler Technologies]**
 - 5. **[Harsco Industrial, Patterson-Kelley]**
 - 6. **[Laars Heating Systems Company; a subsidiary of Bradford White Corporation]**
 - 7. **[Lochinvar, LLC]**
 - 8. **[Precision Boilers]**
 - 9. **[Raypak; a Rheem brand]**
 - 10. **[RBI]**
 - 11. **[RECO USA]**
 - 12. **<Insert manufacturer's name>**
- C. Description: Factory-fabricated, -assembled, and -tested boiler, with tubes sealed into headers pressure tight, and set on a steel base; including insulated jacket, flue-gas vent, combustion-air-intake connections, water supply and return connections, and controls.

D. Heat Exchanger:

1. Finned [copper][steel][or][copper-nickel] tubing with stainless steel baffles.
2. [Bronze][Cast-iron][or][Steel] headers.
3. [Single][Two]-pass, [horizontal][vertical][or][coil] configuration.
4. Tubes shall be sealed in header [with silicone O-ring gaskets][by welding][or][by mechanically rolling tubes in header].

E. Combustion Chamber Internal Insulation: Interlocking panels of refractory insulation, high-temperature cements, mineral fiber, and ceramic refractory tile for service temperatures of up to **2000 deg F (1100 deg C)**.

F. Casing:

1. Jacket: [Sheet metal][or][Stainless steel], with snap-in or interlocking closures.
2. Control Compartment Enclosure: NEMA 250, Type 1A.
3. Finish: [Baked enamel over primer][Baked enamel over galvanizing][Powder coated].
4. Insulation: Minimum [1-inch- (25-mm-)][2-inch- (50-mm-)]<Insert value> thick, mineral-fiber insulation surrounding the heat exchanger.
5. Draft Hood: [Integral][External].
6. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
7. Mounting base to secure boiler[with accessory for mounting on combustible surface].

G. Burner:

1. Burner Tubes and Orifices: Stainless steel, for [natural][propane] gas.[**Mount burner tubes in a slide-out burner drawer for ease of inspection.**]
 - a. Sealed Combustion: Factory-mounted centrifugal fan to draw outside air into boiler and discharge into burner compartment.
 - b. Direct Vent: Factory-mounted centrifugal fan to draw flue gas out of boiler and discharge into boiler vent.
2. Vertical Burner:
 - a. [High-temperature stainless steel][Ceramic] to fire in a 360-degree pattern.
 - b. Burner shall have a viewing port for observation of burner operation and a factory-mounted centrifugal fan to supply [room][outdoor] air[**through a replaceable 99 percent efficient (1-micrometer particles) filter**] to boiler burner.
 - c. Fan shall be controlled to prepurge and postpurge the combustion chamber before firing.
3. Gas Train for Commercial Boilers: Control devices and [full-modulation][on/off][low/high/low][proportional] control sequence shall comply with [AGA][ASME CSD-1][FM Global][Industrial Risk Insurers (IRI)][and][or][UL] requirements. In addition to these requirements, include shutoff cock, pressure regulator, and control valve.
4. Gas Train for Residential Boilers: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
5. Pilot: [Standing][Intermittent-electric-spark][Hot-surface] pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
6. Flue-Gas Recirculation System: Centrifugal fans on burner assembly to recirculate flue gas to decrease emissions to requirements indicated. Complete package integrating burner, fan, damper, fuel train, and controls. Provide interconnecting external ducting if required by manufacturer's design.
7. Motors: Comply with requirements for motors specified in Section 230500 "Common Work Results for HVAC."

H. Hot-Water Boiler Trim:

1. Hot-Water Temperature Controllers: Operating[, **firing rate**,] and high limit.
2. Safety Relief Valve: ASME rated.
3. Pressure and Temperature Gage: Minimum **3-1/2-inch- (89-mm-)** diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.
4. Boiler Air Vent: **[Automatic][Manual]**.
5. Drain Valve: Minimum **NPS 3/4 (DN 20)** hose-end valve.
6. Circulation Pump: Non-overloading, in-line pump with **[split-capacitor]** motor having thermal-overload protection and lubricated bearings; designed to operate at boiler flow rate, pressures, and temperatures.

I. Controls:

1. Boiler operating controls shall include the following devices and features:
 - a. Control transformer.
 - b. Motorized Vent Damper: Interlocked with burner to open before burner starts. If damper fails to open, stop burner operation.
 - c. Set-Point Adjust: Set points shall be adjustable.
 - d. Sequence of Operation:
 - 1) Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
 - 2) Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outdoor-air temperature. At **[0 deg F (minus 17 deg C)]<Insert temperature>** outdoor-air temperature, set supply-water temperature at **[200 deg F (93 deg C)]<Insert temperature>**; at **[60 deg F (15 deg C)]<Insert temperature>** outdoor-air temperature, set supply-water temperature at **[140 deg F (60 deg C)]<Insert temperature>**.
 - e. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
2. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
 - a. High Cutoff: **[Manual][Automatic]** reset stops burner if operating conditions rise above maximum boiler design temperature.
 - b. Water Flow Switch: Automatic-reset paddle-switch shall prevent burner operation on low water flow.
 - c. Blocked Vent Safety Switch: Manual-reset switch factory mounted on draft diverter.
 - d. Rollout Safety Switch: Factory mounted on boiler combustion chamber.
 - e. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
3. DDC System Interface: Factory install hardware and software to enable system to monitor, control, and display boiler status and alarms.
 - a. Hardwired I/O Points:
 - 1) Monitoring: On/off status, **[common trouble alarm][low-water-level alarm]<Insert monitoring point>**.

- 2) Control: On/off operation, [hot-water-supply temperature set-point adjustment]<Insert control point>.
- b. Communication Interface: [ASHRAE 135 (BACnet)][(LonTalk)][Modbus][Industry-accepted, open-protocol]<Insert type of interface> communication interface shall enable control system operator to remotely control on/off operation and capacity of boiler and monitor the boiler operation from an operator workstation. The control features and monitoring points at the boiler-control panel shall be available to the control system through an interface.

2.3 STEEL OR FLEXIBLE WATER-TUBE BOILERS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [Ajax Boiler Inc]
 2. [Bryan Boilers; Bryan Steam LLC]
 3. [Cleaver-Brooks]
 4. [Miura North America, inc.]
 5. [Parker Boiler]
 6. [Raypak; a Rheem brand]
 7. [Rite Engineering & Mfg. Corp.]
 8. [York-Shipley Global; Division of Power Mechanical, Inc.]
 9. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 1. [Ajax Boiler Inc]
 2. [Bryan Boilers; Bryan Steam LLC]
 3. [Cleaver-Brooks]
 4. [Miura North America, inc.]
 5. [Parker Boiler]
 6. [Raypak; a Rheem brand]
 7. [Rite Engineering & Mfg. Corp.]
 8. [York-Shipley Global; Division of Power Mechanical, Inc.]
 9. <Insert manufacturer's name>
- C. Description: Factory-fabricated and [field]-assembled water-tube boiler, with heat exchanger sealed pressure tight, and built on a steel base; including insulated jacket, flue-gas vent, supply and return connections, and controls.
- D. Heat-Exchanger Design, Straight Steel Tubes Rolled into Steel Headers:
 1. Accessible head plates at both ends.
 2. Handholes[or couplings] in headers for waterside inspections.
 3. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
 4. Lifting lugs on top of boiler.
 5. Built-in air separator.
- E. Heat-Exchanger Design, Bent Steel Tubes and Steel Headers:
 1. Tube/Header Connection: [Swaged][Welded].
 2. Water Wall Design: [Waterfall]<Insert design type>.

3. Limit tube configurations to **[two][four]<Insert number>**.
 4. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
 5. Accessible inspection ports in drum, mud legs, and tube manifolds.
 6. Lifting lugs on top of boiler.
 7. Built-in air separator.
- F. Combustion Chamber: Equipped with minimum **[2-1/2-inch (64-mm)][3-inch (75-mm)][4-inch (100-mm)]**, **2700 deg F (1482 deg C)** poured refractory on floor and minimum **[2-inch (50-mm)][3-1/2-inch (89-mm)]<Insert value>** lap-jointed cast refractory with fiber-blanket joint seals on side walls. Combustion chamber shall have flame observation ports in front **[and][or]** back.
- G. Casing:
1. Insulation: Minimum **[2-inch (50-mm) thick, lightweight refractory; 1-inch (25-mm) thick insulating board; galvanized-steel membrane; and] 2-inch (50-mm)** thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber.
 2. Top Flue Connection: Constructed of **[aluminized][or][stainless]** steel.
 3. Jacket:
 - a. Mirror-finish stainless steel, with screw-fastened closures.
 - b. **[Galvanized]** sheet metal, with screw-fastened closures and **[baked-enamel][powder-coated]** protective finish.
 4. Mounting Base: Secures boiler to concrete base.
- H. Draft Control: **[Draft diverter][Barometric damper]**; galvanized-steel assembly with flue-gas thermometer.
- I. Atmospheric Gas Burner:
1. Burner and Orifices: **[Stainless steel][Cast iron]**, for **[natural][propane]** gas.
 2. Gas Train for Commercial Boilers: Control devices and **[full-modulation][on/off][low/high/low]** control sequence shall comply with **[ASME CSD-1][FM Global][NFPA 85][Industrial Risk Insurers (IRI)][and][or][UL]** requirements.
 3. Gas Train for Residential Boilers: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
 4. Pilot: **[Standing][Intermittent-electric-spark]** pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
- J. Forced-Draft Gas Burner:
1. Burner: Welded construction with multivane, stainless steel, flame-retention diffuser for **[natural][propane]** gas. **[Mount burner on hinged access door to permit access to combustion chamber.]**
 2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 3. Gas Train: Control devices and **[modulating][on/off][low/high/low]** control sequence shall comply with **[ASME CSD-1][FM Global][NFPA 85][Industrial Risk Insurers (IRI)][and][or][UL]** requirements.
 4. Pilot: **[Intermittent][Interrupted]-electric-spark** pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
- K. Forced-Draft Oil Burner:
1. Burner: Welded construction with multivane, stainless steel, flame-retention diffuser for fuel oil. **[**

2. **Mount burner on hinged access door to permit access to combustion chamber.** Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 3. Oil Supply: Control devices and **[modulating][on/off][low/high/low]** control sequence shall comply with **[ASME CSD-1][FM Global][NFPA 85][Industrial Risk Insurers (IRI)][and][or][UL]** requirements.
 - a. Oil Pump: Two-stage, gear-type oil pump **[integral to and directly driven by blower]** shall be capable of producing **300-psig (2070-kPa)** discharge pressure and **15-inch Hg (50.7-kPa)** vacuum.
 - b. Oil Piping Specialties:
 - 1) Suction-line, manual, gate valve.
 - 2) Removable-mesh oil strainer.
 - 3) **0- to 30-inch Hg (0- to 101.3-kPa)** vacuum; **0- to 30-psig (0- to 207-kPa)** vacuum-pressure gage.
 - 4) **0- to 300-psig (0- to 2070-kPa)** oil-nozzle pressure gage.
 - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
 4. Pilot: **[Intermittent][Interrupted]**-electric-spark pilot ignition with 100 percent main-valve and pilot-safety-shutoff solenoid using **[cadmium sulfide][UV scanner]** flame-safety control.
- L. Forced-Draft Combination Gas and Oil Burner:
1. Burner: Welded construction with multivane, stainless steel, flame-retention diffuser for fuel oil and **[natural][propane]** gas. **[Mount burner on hinged access door to permit access to combustion chamber.]**
 2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 3. Oil Supply: Control devices and **[modulating][on/off][low/high/low]** control sequence shall comply with **[ASME CSD-1][FM Global][NFPA 85][Industrial Risk Insurers (IRI)][and][or][UL]** requirements.
 - a. Oil Pump: Two-stage, gear-type oil pump **[integral to and directly driven by blower]** shall be capable of producing **300-psig (2070-kPa)** discharge pressure and **15-inch Hg (50.7-kPa)** vacuum.
 - b. Oil Piping Specialties:
 - 1) Suction-line, manual, gate valve.
 - 2) Removable-mesh oil strainer.
 - 3) **0- to 30-inch Hg (0- to 101.3-kPa)** vacuum; **0- to 30-psig (0- to 207-kPa)** vacuum-pressure gage.
 - 4) **0- to 300-psig (0- to 2070-kPa)** oil-nozzle pressure gage.
 - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
 4. Gas Train: Control devices and **[modulating][on/off][low/high/low]** control sequence shall comply with **[ASME CSD-1][FM Global][NFPA 85][Industrial Risk Insurers (IRI)][and][UL]** requirements.
 5. Gas Pilot: **[Intermittent][Interrupted]**-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
 6. Oil Pilot: **[Intermittent][Interrupted]**-electric-spark pilot ignition with 100 percent main-valve and pilot-safety-shutoff solenoid with **[cadmium sulfide][UV scanner]** flame-safety control.
- M. Motors: Comply with requirements for motors specified in Section 230500 "Common Work Results for HVAC" unless more stringent requirements are indicated below:

1. Efficiency: **[Premium efficient]**<Insert requirement>.
2. Enclosure: **[Open dripproof][Totally enclosed][or][Totally enclosed, fan cooled]**.
3. Insulation Class: **[F][H]**<Insert requirement>.
4. Service Factor: **[1.15]**<Insert value>.
5. Motors operated through variable-frequency controllers shall be inverter duty rated according to NEMA MG-1.
6. Motor Sizes: Minimum size as indicated and large enough so driven load does not require motor to operate in service factor.

N. Flue-Gas Recirculation System:

1. Equip boiler with packaged flue-gas recirculation system if required to satisfy emission requirements.
2. Complete package integrating burner, combustion-air blower and damper, fuel train, and controls. Provide interconnecting external ducting if required by manufacturer's design.

O. Hot-Water Boiler Trim:

1. Include devices sized to comply with **[ASME B31.1][ASME B31.9]**.
2. Hot-Water Temperature Controllers: Operating[, **firing rate,**] and high limit.
3. Safety Relief Valve: ASME rated.
4. Pressure and Temperature Gage: Minimum **3-1/2-inch (89-mm)** diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.
5. Boiler Air Vent: **[Automatic][Manual]**.
6. Drain Valve: Minimum **NPS 3/4 (DN 20)** hose-end valve.
7. Tankless Heater: **[Carbon-steel][Bronze]** header with copper-tube heat exchanger, mounted in a port of upper drum and sealed with fiber gasket.
 - a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - b. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

P. Steam Boiler Trim:

1. Include devices sized to comply with **[ASME B31.1][ASME B31.9]**.
2. Pressure Controllers: Operating[, **firing rate,**] and high limit.
3. Safety Relief Valve:
 - a. Size and Capacity: As required for equipment according to 2010 ASME Boiler and Pressure Vessel Code.
 - b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
 - 1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
 - 2) Exhaust Head: Install exhaust head on vent pipe connected to safety relief valve.
4. Pressure Gage: Minimum **3-1/2-inch (89-mm)** diameter. Gage shall have normal operating pressure of about 50 percent of full range.
5. Water Column: Minimum **12-inch (300-mm)** glass gage with gage rods to protect glass, ball check and shutoff cocks, water column blowdown valves, and vacuum breaker. Midpoint of gauge shall be at normal operating water level.

6. Bottom Blowdown Valves: Factory-installed, duty-rated, slow-acting blowdown valves and interconnecting piping same size as boiler nozzle. **[Blowdown valves shall be combination of slow and quick acting as required by ASME B31.1.]**
7. Surface Blowdown Valves: Factory-installed, duty-rated isolation valves and interconnecting piping. **[In addition, provide electrically operated control valve, duty rated, to control total dissolved solids (TDS) through boiler controls.]**
8. Stop Valves: Boiler outlets, except safety relief valves, shall be equipped with stop valve in an accessible location as near as is practical to boiler nozzle and same size or larger than nozzle. Valves larger than **NPS 2 (DN 50)** shall have rising stem.
9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
 - a. Feedwater Valves: Factory-installed, duty-rated stop and check valves and interconnecting piping. Stop valves larger than **NPS 2 (DN 50)** shall have rising stem.
 - b. Factory-installed, three-valve bypass arrangement with modulating control valve positioned between duty-rated stop valves, bypass piping with throttling valve, check valve, and interconnecting piping. Stop and throttling valves larger than **NPS 2 (DN 50)** shall have rising stem. Modulating control valve shall have the following features and characteristics:
 - 1) Duty rated with electric operator to control water level through boiler controls.
 - 2) Equal percentage flow characteristic.
 - 3) Valve Flow: **[Indicated on Drawings][1.25 times boiler output]<Insert requirement>**.
 - 4) Valve Pressure and Temperature Rating: Equal to boiler.
 - 5) Shut-off Leakage: **[0.0001]<Insert number>** percent of valve coefficient.
10. Chemical Injection Assembly: Factory-installed, duty-rated injection quill with ball check valve and isolation valve compatible with dispensed chemical.
11. Sample Cooler: Factory **[installed][or][furnished for field installation]**, with **[needle]** valve for each connection. **[Constructed of 316 stainless steel.]**
12. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in a port of upper manifold and sealed with fiber gasket.
 - a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - b. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

Q. Controls:

1. Boiler operating controls shall include the following devices and features:
 - a. Control transformer(s) with fuse protection, as required by manufacturer, to implement requirements indicated. Provide transformer with 25 percent spare capacity.
 - b. Set-Point Adjust: Operating and alarm set points shall be field adjustable.
2. Pressure Control for Steam Boilers:
 - a. Operating-Pressure Control: Factory wired and mounted to control boiler to maintain boiler at constant pressure within **[2]<Insert number>** percent of set point.
 - b. High-Pressure Cutoff with Automatic Reset: Control stops burner if operating conditions rise above normal operating-pressure set point. Set point shall be adjustable.
 - c. High-Pressure Cutoff with Manual Reset: Control stops burner operation upon reaching adjustable high limit set point that is below safety valve setting.

3. Water-Level Control for Steam Boilers:
 - a. Operating Water-Level Control: **[Cycle feedwater pump(s)][Operate feedwater pump(s) continuously and modulate boiler feedwater valve]** for water-level control.
 - b. Low-Water Cutoff Switch: **[Electronic][Float and electronic]** probe shall prevent burner operation on low water. Cutoff switch shall be **[manual][automatic]**-reset type.
 - c. Auxiliary Low-Water Cutoff Switch: **[Electronic][Float and electronic]** probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
 - d. Microprocessor-based control.
 - e. Accuracy within **[0.01 inch (0.25 mm)]<Insert value>**.
 - f. Visual indication of level, alarms, and errors through alphanumeric display.
 - g. Features:
 - 1) Continuous water-level indication.
 - 2) Low-water cutoff and alarm.
 - 3) High-water alarm.
 - 4) Low- and high-water warning.
 - 5) Control of feedwater pump.
 - 6) Control of modulating feedwater control valve.
 - 7) Continuous monitoring of float operation.
 - 8) Column blowdown detection and reminder.
 - 9) Auxiliary low-water cutoff check.
 - 10) Auto and manual reset.
 - 11) Alarm annunciation.
 - 12) **<Insert feature>**.
4. Operating Controls for Hot-Water Boilers:
 - a. Sequence of Operation:
 - 1) Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outdoor-air temperature. At **[0 deg F (minus 17 deg C)]<Insert temperature>** outdoor-air temperature, set supply-water temperature at **[200 deg F (93 deg C)]<Insert temperature>**; at **[60 deg F (15 deg C)]<Insert temperature>** outdoor-air temperature, set supply-water temperature at **[140 deg F (60 deg C)]<Insert temperature>**.
 - 2) Indicated on Drawings.
 - 3) **<Insert requirements>**.
5. Multiple Boiler Operation: Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
6. Boiler Emergency Shutdown: Interlock with field-installed boiler emergency shutdown switch to shut down boiler when activated. Manufacturer to furnish break-glass-type switch with permanent nameplate titled "Boiler Emergency Shutdown" for field installation.
7. Chemical Feed System Interface: Dry contacts to interface control and operation of chemical feed pump.
8. Burner Safety Controls for Steam Boilers: To maintain safe operating conditions, burner safety controls limit burner operation.
 - a. High Cutoff: **[Automatic][and][Manual]** reset stops burner if operating conditions rise above maximum boiler operating pressure.
 - b. Low-Water Cutoff Switch: Float and electronic probe shall prevent burner operation on low water. Cutoff switch shall be automatic-reset type.
 - c. Auxiliary Low-Water Cutoff Switch: Float and electronic probe shall prevent burner

- d. operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
 - d. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
9. Burner Safety Controls for Hot-Water Boilers: To maintain safe operating conditions, burner safety controls limit burner operation.
- a. High Cutoff: **[Automatic][and][Manual]** reset stops burner if operating conditions rise above boiler design temperature.
 - b. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be **[manual][automatic]**-reset type.
 - c. Auxiliary Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
 - d. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
10. Burner Flame Safeguard Controls:
- a. Factory equipped with flame safeguard control and infrared flame scanner.
 - b. Microprocessor-based, solid-state control having sequence and flame-on visual indication and fault code indications of flame safeguard trip functions.
 - c. Control shall include dynamic self-check logic.
 - d. Control shall have a fixed operating sequence incapable of being manually altered that includes start, prepurge, pilot and main fuel ignition run, and postpurge cycles.
 - e. Control shall be nonrecycle type for maximum safety that shall shut down the burner and indicate, as a minimum, the following trip functions:
 - 1) Pilot and main flame failure.
 - 2) High- and low-fire proving switch faults.
 - 3) Running interlocks open.
 - 4) False flame signal and fuel valve open.
 - f. Control shall include a run/test switch to allow interruptions to sequence just after prepurge and during pilot ignition trial, and run cycles for adjustments to firing rate motor, damper linkages, and pilot flame for minimum turndown tests.
11. Combustion-Air Controls: Factory equipped with motor-operated combustion-air damper and blower control to regulate burner fire according to load demand.
12. Oxygen Trim Control:
- a. Provide oxygen trim system to continuously monitor and display oxygen concentrations in boiler flue gas and adjust fuel and airflow to maintain an adjustable oxygen-level set point.
 - b. System shall compensate for changes in ambient temperature, barometric pressure, humidity, and variations in fuel characteristics.
13. Surface Blowdown Control: Provide a conductivity sensor and control circuitry to operate an automatic control valve in surface blowdown piping to maintain total dissolved solids (TDS) within boiler manufacturer's prescribed level.
14. DDC System Interface: Factory install hardware and software to enable system to monitor, control, and display boiler status and alarms.
- a. Hardwired I/O Points:
 - 1) Monitoring: On/off status, **[common trouble alarm][low-water-level alarm]<Insert monitoring points>**.
 - 2) Control: On/off operation, **[hot-water-supply temperature set-point**

adjustment][steam pressure adjustment]<Insert control points>.

- b. Communication Interface: **[ASHRAE 135 (BACnet)][(LonTalk)][Modbus][Industry-accepted, open-protocol]<Insert type of interface>** communication interface shall enable control system operator to remotely control on/off and capacity of boiler and monitor the boiler operation from an operator workstation. Control features are available, and monitoring points are displayed locally at boiler control panel through the interface.
15. Integrated Boiler Control System:
- a. Integral control of burner management for flame safety, boiler modulation, and operator interface functions with features and functions indicated.
 - b. Factory preconfigured.
 - c. Utilizing solid-state controls and sensors to provide various control functions, including the following:
 - 1) Automatic sequencing of the boiler through standby, prepurge, pilot flame establishing period, main flame establishing period, run, flame proving and lockout, and postpurge.
 - 2) Full modulating control of air and fuel through Proportional-Integral-Derivative (PID) algorithm.
 - 3) Thermal shock protection.
 - 4) High and low limit alarms and shutdowns.
 - d. Local operator interface through nominal **[10-inch (250-mm)]<Insert size>** color touch screen graphical display for setup, monitoring, and data acquisition.
 - 1) Manual control of the boiler firing rate using control screens to increment or decrement firing rate.
 - 2) Indication of burner management controller status and diagnostics.
 - 3) Display of system alarms and faults.
 - 4) Display of history of alarms and faults.
 - 5) Display of recommendations for troubleshooting of fault conditions.
 - 6) Display of water-level indication and alarm(s).
 - 7) Stack flue-gas, combustion-air, and shell water-temperature indication.
 - 8) Boiler efficiency calculation and display.
 - 9) Low-fire hold with minimum temperature control.
 - 10) Assured low-fire cutoff (ALFCO).
 - 11) High stack temperature annunciation with auto cutoff.
 - 12) Audible alarm and silencing through touch screen intervention.
 - e. Fully integrated control of the following:
 - 1) Blower operation and combustion-air damper for varying operating conditions.
 - 2) Oxygen trim and monitoring to compensate for combustion-air variations.
 - 3) Parallel positioning for independent fuel and air control for enhanced fuel efficiency.
 - 4) Multiple boiler lead/lag control with hot standby.
 - 5) Draft control for maintaining proper and consistent draft for enhanced fuel efficiency.
 - 6) **<Insert additional features>.**
 - f. E-mail and paging feature to multiple contacts via Internet and phone line independent of control system interface.
 - g. LAN/WAN interface with remote monitoring software to allow remote monitoring independent of control system interface.

16. Control Enclosures:

- a. NEMA 250, Type [1]<Insert type>.
 - 1) Provide enclosure with integral vents, fans, heater, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
- b. Wiring shall be numbered and color-coded to match wiring diagram. [**Provide a laminated wiring diagram located inside enclosure.**]
- c. Mounted on boiler assembly at a location convenient to operator.
- d. Provide hinged full-size door with key lock. Provide common key for all locks.
- e. Enclosure shall consist of multiple sections divided by a partition with a separate hinged door for each section. One section shall house low-voltage controls and other section shall house line voltage controls.
- f. Enclosure shall house the following:
 - 1) Control transformers with fuses.
 - 2) Labeled terminal strips.
 - 3) Controller(s) to provide control and alarm functions indicated.
 - 4) Audible indication of safety alarms.
- g. Face of enclosure shall provide the following:
 - 1) Visual indication of operating components and alarms.
 - 2) Auto/local capability to allow operator to manually operate boiler locally.
 - 3) Audible alarm-silence capability.
 - 4) Labels for switches, lights, and displays to provide clear indication of service.

17. Control Instrument Enclosures: Control instruments and devices that are mounted on the boiler assembly and cannot be installed inside the control enclosure shall have same or higher level of protection indicated for control enclosures.

18. Control Cable and Wire:

- a. Control cable and wiring shall be numbered and color-coded to match wiring diagram.
- b. Install cable and wiring located outside of enclosure(s) in a [**metal**] raceway. Use flexible conduit to make final terminations. Provide watertight installation for applications exposed to moisture.

2.4 ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. Enclosure: NEMA 250, Type [1]<Insert type>.
 - a. Enclosure shall have integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
 - b. Mounted on boiler assembly at a location convenient to operator.
 - c. Enclosure shall have hinged full-size door with key lock with common key for all locks.
2. Wiring shall be numbered and color-coded to match wiring diagram. [**Provide a laminated wiring diagram located inside enclosure.**]

3. Install factory wiring outside of an enclosure in a **[metal]** raceway. Make final connections to motors using flexible conduit. Provide watertight installation for applications exposed to moisture.
4. Field power interface shall be to **[fused disconnect switch][nonfused disconnect switch][circuit breaker]**. Withstanding rating of disconnecting means shall protect equipment. Coordinate requirements with field electrical power source.
5. Provide branch power circuit to each motor and to controls **[with disconnect switch or circuit breaker]**.
6. Provide each motor with NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
7. Provide transformer with fuses and power wiring to power a 20-A 120-V duplex receptacle mounted in each boiler control panel for use in connecting analytical and testing equipment.

2.5 VENTING KITS

- A. Vent Damper: Motorized; UL listed for use on atmospheric burner boiler equipped with draft hood; motor to open and close damper; stainless steel vent coupling and damper blade; keyed wiring harness connector plug; and dual-position switches to permit burner operation.
- B. Kit: Complete system, **[ASTM A959, Type 29-4C]** stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap, and sealant.
- C. Combustion-Air Intake: Stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.6 CAPACITIES AND CHARACTERISTICS

- A. Heating Medium: **[Hot water][Steam]**.
- B. Design Pressure and Temperature Rating: **[160 psig (1100 kPa), 250 deg F (120 deg C)]<Insert values>**.
- C. Design Pressure Rating:
 1. **[60 psig (420 kPa)][100 psig (690 kPa)][140 psig (966 kPa)][160 psig (1100 kPa)]<Insert value>**.
 2. **[15 psig (104 kPa)][150 psig (1035 kPa)][250 psig (1725 kPa)]<Insert value>**.
- D. Safety Relief Valve Setting: **<Insert psig (kPa)>**.
- E. Entering-Water Temperature: **<Insert deg F (deg C)>**.
- F. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
- G. Design Water-Flow Rate: **<Insert gpm (L/s)>**.
- H. Design Pressure Drop: **<Insert psig (kPa)>**.
- I. Steam Operating Pressure: **<Insert psig (kPa)>**.
- J. Steam-Flow Rate: **<Insert lb/h (kg/s)>**.
- K. Minimum Efficiency AFUE: **<Insert number>** percent.

- L. Minimum Thermal Efficiency: **<Insert number>** percent.
- M. Minimum Combustion Efficiency: **<Insert number>** percent.
- N. Fuel-to-[**Steam**][**Water**] Efficiency: **<Insert number>** percent.
- O. Number of Passes: [**One**][**Two**]**<Insert number>**.
- P. Gas Input: **<Insert MBh (kW)>**.
- Q. Gas Input Flow: **<Insert cfh (mL/s)>**.
- R. Gas Pressure: **<Insert psig (kPa)>**.
- S. Oil Input: **<Insert MBh (kW)>**.
- T. Oil Input Flow: **<Insert gph (mL/s)>**.
- U. Output Capacity: **<Insert MBh (kW)>**.
- V. Tankless Water Heater:
 - 1. Design Water Flow: **<Insert gpm (L/s)>**.
 - 2. Design Pressure Drop: **<Insert psig (kPa)>**.
 - 3. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 - 4. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
- W. Burner Blower:
 - 1. Motor Horsepower: **<Insert number>** hp.
- X. Electrical Characteristics:
 - 1. Volts: [**115**][**208**][**230**][**460**]**<Insert number>** V.
 - 2. Phase: [**Single**][**Three**].
 - 3. Hertz: [**50**][**60**]**<Insert number>** Hz.
 - 4. Full-Load Amperes: **<Insert number>** A.
 - 5. Minimum Circuit Ampacity: **<Insert number>** A.
 - 6. Maximum Overcurrent Protection: **<Insert number>** A.
- Y. Sound (decibels, A weighted): **<Insert number>** dB.

2.7 SOURCE QUALITY CONTROL

- A. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.
- B. Burner and Hydrostatic Test:
 - 1. Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve performance requirements indicated.
 - 2. Perform hydrostatic test of pressure vessel, piping, and trim of assembled boiler.
- C. Witness Testing:

1. Allow Owner access to witness source quality-control testing of boilers.
2. Notify [Architect][Owner][15]<Insert number> days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and flue; piping; controls; and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
 1. Boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for flue, piping, controls, and electrical connections.
- B. Examine areas where boilers will be installed for suitable conditions.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF BOILERS

- A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- B. Equipment Mounting:
 1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install gas-fired boilers according to NFPA 54.
- D. Install oil-fired boilers according to NFPA 31.
- E. Assemble boiler tubes in sequence and seal each tube joint.
- F. Assemble and install boiler trim, components, and accessories that are not factory installed.
- G. Install control and electrical devices furnished with boiler that are not factory mounted.
- H. Install control and power wiring to field-mounted control and electrical devices furnished with boiler that are not factory installed.
- I. Perform boil-out and cleaning procedures according to manufacturer's written instructions after completion of hydrostatic testing and before performing other field tests. **Boiler manufacturer's factory-authorized representative shall witness boil-out and cleaning procedures.** Following boil-out and cleaning procedures, boiler shall be washed and flushed until water leaving boiler is clear.
- J. Protect boiler fireside and waterside from corrosion.

1. Before boiler is filled with water, protect by dry storage method recommended by boiler manufacturer.
2. After boiler is filled with water, and left not fired for more than [10]<Insert number> days, protect by wet storage method recommended by boiler manufacturer.
3. Chemical Treatment: Quality of water in boilers shall be maintained by a professional water-treatment organization that shall provide on-site supervision to maintain the required water quality during periods of boiler storage as well as during operating, standby, and test conditions. Refer to <Insert applicable Section number and title> for additional requirements.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to boiler(s), allow space for service and maintenance.
- C. Connect gas piping to boiler gas-train inlet with dirt leg, shutoff valve, and union or flange. Piping shall be at least full size of gas-train connection. Provide a reducer if required.
- D. Connect oil piping to oil-train connection with dirt leg, shutoff valve, and union. Piping shall be at least full size of oil-train connection. Provide a reducer if required. Provide drain valve with threaded plug at piping low point.
- E. Connect hot-water piping to supply- and return-boiler connections with shutoff valve and union or flange at each connection.
- F. Connect steam and condensate piping to supply-, return-, and blowdown-boiler connections with union or flange at each connection. Provide each connection with shutoff valve if shutoff valves are not factory furnished with boiler trim. [**Provide check valves in blowdown piping of each boiler that connects multiple boilers.**]
- G. Install piping from safety relief valves to nearest floor drain.
- H. Install piping from safety valves and drip-pan elbows. Extend piping from safety valves and terminate to vent outdoors. Extend piping from drip-pan elbow drain to nearest floor drain.
- I. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
- J. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.
 1. Provide a temperature-controlled nonpotable domestic cold water source to cool hot equipment drains to deliver a discharge temperature of <Insert temperature>.
- K. Connect chemical-treatment piping to each boiler chemical-treatment connection with check valve and isolation valve.

3.4 FLUE CONNECTIONS

- A. Boiler Flue Venting:

1. Install venting kit and combustion-air intake.
2. Connect full size to boiler connections. Comply with requirements in Section 235123 "Gas Vents."

- B. Connect breeching to full size of boiler outlet. Comply with requirements in [Section 235116 "Fabricated Breechings and Accessories"]**[and]**[Section 235133 "Insulated Sectional Chimneys"] for venting materials.
- C. Install flue-gas recirculation duct from vent to burner if not factory furnished and installed. Comply with requirements in Section 235116 "Fabricated Breechings and Accessories" for recirculation duct materials.
- D. Install easily accessible test ports for field testing of flue gas from each boiler.

3.5 ELECTRICAL POWER CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between boilers and other equipment to interlock operation as required, to provide a complete and functioning system.
- C. Connect control wiring between boiler control interface and **[DDC control system]**<Insert system description> for remote monitoring and control of boilers. Comply with requirements in **[Section 230923 "Direct Digital Control (DDC) System for HVAC"]**<Insert Section number and title>.

3.7 NETWORK AND PHONE CONNECTIONS

- A. Connect LAN/WAN network cable to boiler controls to provide connectivity for remote monitoring through integrated boiler control system.
- B. Connect phone system cable to boiler controls to provide connectivity for remote monitoring and alarm notification through integrated boiler control system.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections**[with the assistance of a factory-authorized service representative]**:
1. Perform installation and startup checks according to manufacturer's written instructions.

2. Hydrostatic Leak Test: Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
 - b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and **[water temperature][steam pressure]**.
 - c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Boiler will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. Occupancy Adjustments: When requested within **[12 months of date of Substantial Completion]<Insert time period>**, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.
- G. Performance Tests:
 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 2. Boilers shall comply with performance requirements indicated, as determined by field-performance tests. Adjust, modify, or replace equipment in order to comply.
 3. Perform field-performance tests to determine the capacity and efficiency of the boilers.
 - a. For dual-fuel boilers, perform tests for each fuel.
 - b. Test for full capacity.
 - c. Test for boiler efficiency at **[low fire, 10, 20, 30, 40, 50, 60, 70, 80, 90, and high fire (100)]<Insert range>** percent of full capacity. Determine and document efficiency at each test point.
 4. Test each safety valve. Record pressure at valve blowdown and reset. Test valve(s) with boiler operating at full capacity to ensure valve has capacity to prevent further rise in pressure.
 5. For boilers equipped with automatic oxygen trim control, conduct tests with automatic oxygen trim control on manual at zero trim and record performance. Repeat tests with automatic oxygen trim control under automatic control and record performance.
 6. Repeat tests until results comply with requirements indicated.
 7. Provide measurement and analysis equipment required to determine performance.
 8. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
 9. Notify **[Architect][Owner][20]<Insert number>** days in advance of test dates.
 10. Document test results in a report and submit with informational submittals.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain boilers. **[Video training sessions and provide electronic copy of video to Owner.]** Refer to Section 017900 "Demonstration and Training."



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

END OF SECTION 23 52 33 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 52 33 13	23 52 33 00	Water-Tube Boilers
23 52 33 16	23 52 33 00	Water-Tube Boilers
23 52 36 00	23 52 39 00	Fire-Tube Boilers



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 52 39 00 - FIRE-TUBE BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Horizontal fire-tube boilers.
2. Vertical fire-tube boilers.
3. Fire box boilers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product, include the following:

1. Construction details, material descriptions, dimensions, and weights of individual components, profiles, and finishes for boilers.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.
3. Predicted boiler efficiency while operating at design capacity and at varying part loads with basis indicated.
4. Predicted emissions levels while operating at design capacity and at varying part loads with basis indicated. Indicate operation that produces worst-case emissions.
5. Technical data for refractory and insulation, including temperature rating, thermal performance, attachment, and arrangement.
6. Calculations showing predicted surface temperature of boiler jacket with basis indicated.
7. Force and moment capacity of each piping and flue connection.
8. Dimensioned location of low, high, and normal water level, showing operating set point and each alarm set point.
9. Temperature and pressure rating, size, and materials of construction for boiler trim components, including piping, fittings, flanges, unions, and valves. Provide valve manufacturer's product data for each valve furnished. For safety valves, include trip and reset settings and flow capacity.
10. Manufacturer's product data showing size, scale range, and accuracy of thermometers and pressure gages.
11. Pressure rating, size, and materials of construction for boiler fuel train components including piping, fittings, flanges, unions, switches, and valves. Provide manufacturer's product data for each valve and switch furnished.
12. Detailed information of controls, including product data with technical performance, operating characteristics, and sequence of operation.
13. Product data for each motor, including performance, operating characteristics, and materials of construction.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Design calculations and base details, signed and sealed by a qualified professional engineer.
 - a. Design Calculations: Calculate requirements for selecting **[vibration isolators and]** seismic restraints and for designing bases.



- b. Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- 4. Include diagrams for power, signal, and control wiring. Differentiate between factory and field installation.
- 5. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan and elevation views, drawn to **<Insert scale>** scale, indicating equipment manufacturers' service clearances, structure and base attachment, piping, power, controls, and flues. Each view shows a screened background with the following:
 - 1. Column grids, beams, columns, and concrete housekeeping pads.
 - 2. Room layout with walls, floors, and roofs, including each room name and number.
 - 3. Equipment and products of other trades that are located in vicinity of boilers and are part of final installation, such as lighting, fire-suppression systems, and plumbing systems.
- B. Seismic Qualification Certificates: For boilers, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Installation instructions.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranty: For special warranty.
- G. Other Informational Submittals:
 - 1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
 - 2. Startup service reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For boilers, components, and accessories to include in emergency, operation, and maintenance manuals.
- B. Spare Parts List: Recommended spare parts list with quantity for each.
- C. Touch-up Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.



- D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Tool kit to include the following:
 - 1. A tool kit specially designed by boiler manufacturer for use in servicing boiler(s) furnished.
 - 2. Special tools required to service boiler components not readily available to Owner service personnel in performing routine maintenance.
 - 3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Boiler Tool Kit." Text size shall be at least **1 inch (25 mm)** high.
 - 4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least **0.5 inch (13 mm)** high.
- B. Touch-up Paint: **[32 oz. (1 L)]<Insert volume>** container of paint used for finish coat. Label on outside of container shall have a detailed description of paint to allow for procurement of a matching paint in the future.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Ship boilers from the factory free of water. Drain water and blow dry with compressed air if required to remove all water before shipping.
- B. Cover and protect flue, electrical controls, and piping connections before shipping. Protect and seal openings and connections with blinds, caps, plugs, and other materials during delivery, storage, and handling.
- C. Protect boiler components with removable temporary enclosures to prevent damage during shipping, storage, and installation.
- D. Package boiler for export shipping in totally enclosed **[bagging][crate][crate with bagging]**.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace front- and rear-door refractories and heat exchangers of boilers that fail in materials or workmanship within specified warranty period.
 - 1. Horizontal Fire-Tube and Firebox Boilers: Refractory in front and rear doors, **[10]<Insert number>** years from date of startup by factory-authorized personnel.
 - 2. Vertical Fire-Tube Boilers and Heat Exchanger: **[Five]<Insert number>** years from date of Substantial Completion, if following water-treatment program recommended by manufacturer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fuel-to-**[steam][water]** efficiency indicated shall be based on the following:
 - 1. ASME Performance Test Code (PTC) 4, **[Input-Output][Heat Loss]** method.
 - 2. **<Insert test requirement>**.

3. Test Operating Conditions:

- a. Ambient Temperature: **<Insert temperature>**.
- b. Ambient Relative Humidity: **<Insert relative humidity>**.
- c. Percent Excess Air in Exhaust Flue Gas: **[15]<Insert number>**.
- d. Fuel Heating Value: **<Insert value>**.

B. Gas-Fired Boiler Emissions: Not to exceed allowable ambient air quality standards in governing jurisdiction and indicated values.**1. Carbon monoxide:**

- a. **[50]<Insert number>** parts per million at any point from 100 percent to **[50]<Insert number>** percent fire.
- b. **[150]<Insert number>** parts per million at any point below **[50]<Insert number>** percent fire.

2. Nitrogen compounds: **[30][20][10]<Insert number>** parts per million (dry volume basis and corrected to **[3]<Insert number>** percent oxygen) at any point from 100 percent to low fire.
3. Sulfur compounds: **[One]<Insert number>** part per million (dry volume basis and corrected to **[3]<Insert number>** percent oxygen) at any point from 100 percent to low fire.
4. Hydrocarbon and Volatile Organic Compounds: **[10]<Insert number>** parts per million (dry volume basis and corrected to **[3]<Insert number>** percent oxygen) at any point from 100 percent to low fire.
5. Particulate Matter: **[0.01 lb/MMBtu]<Insert value>**.
6. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.

C. Oil-Fired Boiler Emissions: Not to exceed allowable ambient air quality standards in governing jurisdiction and indicated values.**1. Carbon Monoxide:**

- a. **[50]<Insert number>** parts per million at any point from 100 percent to **[50]<Insert number>** percent fire.
- b. **[150]<Insert number>** parts per million at any point below **[50]<Insert number>** percent fire.

2. Nitrogen Compounds: **[30][20][10]<Insert number>** parts per million (dry volume basis and corrected to **[3]<Insert number>** percent oxygen) at any point from 100 percent to low fire.
3. Sulfur Compounds: **[One]<Insert number>** part per million (dry volume basis and corrected to **[3]<Insert number>** percent oxygen) at any point from 100 percent to low fire.
4. Hydrocarbon and Volatile Organic Compounds: **[10]<Insert number>** parts per million (dry volume basis and corrected to **[3]<Insert number>** percent oxygen) at any point from 100 percent to low fire.
5. Particulate Matter: **[0.01 lb/MMBtu]<Insert number>**.
6. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.

D. Multiple Boiler Operation: Equip individual boilers in multiple boiler applications with integral controls to provide multiple boiler operation for optimum system performance, energy efficiency, and the following:

1. Equalize runtime of boilers in service.
2. Operate multiple boilers hot to minimize disruption of service in the event of single boiler failure.
3. Configure controls so any boiler can be taken out of service with power disconnected and not impact multiple boiler operation.
4. **<Insert requirement>**.

- E. Seismic Performance: Boiler shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
1. The term "withstand" means "the boiler will remain in place without separation of any parts when subjected to the seismic forces specified[**and the boiler will be fully operational after the seismic event**]."
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- F. Sound: Boiler sound level, measured according to parameters defined in ABMA publication "Boiler 304 Measurement of Sound from Steam Generators" shall not exceed **<Insert number>** dBA.
- G. Steam Quality: **[99][99.5]<Insert number>** percent dry[**and saturated**].
- H. Operation Following Loss of Normal Power:
1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to back-up power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a back-up power source or through normal power if restored before back-up power is brought online.
 2. Refer to Drawings for equipment served by back-up power systems.
 3. Provide means and methods required to satisfy requirement even if not explicitly indicated.
- I. Outdoor Installations:
1. Boiler shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a **[25]<Insert number>** -year period, with minimal degradation due to exposure to outdoor ambient conditions.
 2. Boilers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past **[30]<Insert number>** -year period. Provide as part of boiler package, products such as combustion-air pre-heaters, and other means and methods required.
- J. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- K. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.
- L. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- M. ISO 14000 Certification: Boiler manufacturer to provide certification stating that it has self-certified its company to ISO 14000.
- N. UL Compliance: Test Boilers for compliance with **[UL 726][UL 726 and UL 795][UL 795]**. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

2.2 HORIZONTAL FIRE-TUBE BOILERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide**

products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Burnham Hydronics]
2. [Cleaver-Brooks]
3. [Green Boiler Technologies]
4. [Hurst Boiler & Welding Company, Inc.]
5. [IBC Technologies; a Rheem brand]
6. [Johnston Boiler Company]
7. [L.E.S., Inc.]
8. [Lattner Boiler Manufacturing]
9. [Superior Boiler Works, Inc]
10. [York-Shipley Global; Division of Power Mechanical, Inc.]
11. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Burnham Hydronics]
2. [Cleaver-Brooks]
3. [Green Boiler Technologies]
4. [Hurst Boiler & Welding Company, Inc.]
5. [IBC Technologies; a Rheem brand]
6. [Johnston Boiler Company]
7. [L.E.S., Inc.]
8. [Lattner Boiler Manufacturing]
9. [Superior Boiler Works, Inc]
10. [York-Shipley Global; Division of Power Mechanical, Inc.]
11. <Insert manufacturer's name>

C. Pressure Vessel Design: [Dry-][or][water]back design with the following:

1. [One][Two][Three][or][Four] pass(es).
2. Minimum Heat-Exchanger Surface: [5 sq. ft./bhp (2.1 sq. m/10 kW)][As required to achieve performance indicated]<Insert value>.
3. Provisions for lifting boiler in-place.

D. Base:

1. Factory-mounted pressure vessel and other boiler components on steel saddles or supports that are fastened securely to a structural steel base that is constructed to make a complete self-supported unit requiring only a flat level surface for support.
2. Base included with attachments if required to secure boiler to structure.
3. Manufacturer's standard provisions for lifting include the following.
 - a. Designed for handling and installation conditions encountered.
 - b. Sufficient to carry total weight of fully assembled boiler with a safety factor of [1.2]<Insert value>.

E. Shell:

1. Horizontal, cylindrical, steel pressure vessel of size to satisfy performance requirements indicated.
2. Manholes and Handholes:

- a. Manhole for waterside inspection and access.
 - b. Handholes at front and rear of boiler for waterside inspections.
 - c. According to 2010 ASME Boiler and Pressure Vessel Code.
3. Hot-Water Boilers:
 - a. Supply- and return-water piping connections.
 - b. Connections with safety relief valve(s).
 - c. Drain connection(s), each with drain valve, at shell low point.
 - d. Connections for other trim indicated.
 - e. Built-in air separator.
4. Steam Boilers:
 - a. Connections for steam supply, feedwater, level controls, and chemical treatment.
 - b. Baffle in shell below steam outlet to provide dry steam with no water carry over.
 - c. Bottom and surface blowdown connections.
 - d. Connections with safety relief valve(s).
 - e. Connections for other trim indicated.
- F. Furnace:
 1. Welded cylindrical steel chamber that is welded to steel tube sheets.
 2. Arranged to provide uniform heat distribution under all firing conditions with no flame impingement on any refractory-covered or waterbacked surface.
 3. Surrounded by water without interfering with natural circulation of water within shell.
 4. Positioned from shell to inhibit unequal thermal stresses during operation.
- G. Fire Tubes:
 1. Steel, seamless or resistance welded.
 2. Fitted in accurately sized holes in tube sheets and **[rolled][or][welded]** in place.
 3. Aligned to prevent noticeable deformation with undue stress when boiler is put in service.
 4. Tube and tube sheet assembly shall be water- and gastight.
 5. Arranged not to interfere with natural circulation of water in shell or to inhibit cleaning and flushing of water sides.
 6. Readily removable from one end of boiler.
 7. Provided without spinners, turbulators, and other inserted devices.
- H. Flue:
 1. Flanged connection located along top centerline of boiler and capable of supporting a field-installed flue stack with a weight of at least **[2000 lb (8.9 kN)]<Insert weight>**.
 2. Equip boiler flue with bimetal thermometer in a stainless steel case, with angle position adjustment and nominal **[5-inch (120-mm)]<Insert size>** diameter face having a graduated scale and range of approximately **[1.5]<Insert number>** times the outlet temperature. Mount thermometer in a Type 316 stainless steel thermowell that is located in a visible location to indicate flue-gas temperature.
- I. Front and Rear Doors:
 1. **[Bolted][hinged][or][davitd]**, sealed with heat-resistant gaskets and fastened with lugs and cap screws.
 2. Designed so tube sheets and flues are fully accessible for inspection or cleaning when doors are open **[without the need to disconnect burner, blower, and fuel piping]**.
 3. Include observation ports in doors at both ends of boiler for inspection of flame conditions.

4. Door **[refractory][or][and][insulation]** shall be accessible for inspection and maintenance.
5. Reinforce doors of dryback boilers to limit deflection due to thermal stresses and burner combustion pulsations to prevent progressive cracking and loosening of refractory.

J. Refractories:

1. Refractories retained shall withstand temperature occurring under maximum load conditions.
2. Formed or cast-in sections shall be easily replaceable through factory openings.
3. Secure refractory sections in position to withstand vibration and shock occurring during shipment, and to withstand burner combustion pulsations.
4. Where used for the burner combustion ring and rear or target baffle, refractories shall have a parametric cone equivalent of not less than 33.
5. Provide refractory for doors and end covers exposed to temperatures of **[600 deg F (316 deg C)]<Insert value>** and higher.

K. Insulation:

1. Minimum **2-inch- (50-mm-)** thick, mineral-fiber insulation surrounding the boiler shell and secured in place to prevent sagging or displacement.
2. Insulation of sufficient density or attached with reinforcement to prevent permanent deformation of protective jacket when subjected to an impact force of **<Insert value>** and forces associated with service personnel walking, kneeling, and laying on boiler while performing service.
3. Insulating value sufficient to limit exterior surface temperature of pressure vessel jacket, doors, and end covers from exceeding **<Insert temperature>** while operating in an ambient environment with a temperature of **<Insert temperature>**, surface wind velocity of **<Insert velocity>**, and boiler operating at full capacity.

L. Jacket: **[Galvanized sheet][Sheet]** metal, with factory-applied protective finish.

1. Nominal Thickness: Not less than **[0.030 inch (0.8 mm)][0.048 inch (1.2 mm)]<Insert thickness>**.
2. Preformed shape to follow a smooth and uniform contour of pressure vessel and encapsulating insulation.
3. Consisting of multiple removable sections attached with corrosion-resistant screw-fasteners to facilitate removal and replacement multiple times.
4. Painted after assembly.

2.3 VERTICAL FIRE-TUBE BOILERS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Columbia Boiler Company]**
2. **[Fulton Boiler Works, Inc]**
3. **[Harsco Industrial, Patterson-Kelley]**
4. **[Hurst Boiler & Welding Company, Inc.]**
5. **[IBC Technologies; a Rheem brand]**
6. **[L.E.S., Inc.]**
7. **[Lattner Boiler Manufacturing]**
8. **[Lochinvar, LLC]**
9. **[Precision Boilers]**
10. **[PVI; A WATTS Brand]**
11. **[Raypak; a Rheem brand]**

12. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Columbia Boiler Company]
 2. [Fulton Boiler Works, Inc]
 3. [Harsco Industrial, Patterson-Kelley]
 4. [Hurst Boiler & Welding Company, Inc.]
 5. [IBC Technologies; a Rheem brand]
 6. [L.E.S., Inc.]
 7. [Lattner Boiler Manufacturing]
 8. [Lochinvar, LLC]
 9. [Precision Boilers]
 10. [PVI; A WATTS Brand]
 11. [Raypak; a Rheem brand]
 12. <Insert manufacturer's name>
- C. Description: Factory-fabricated, -assembled, and -tested, vertical fire-tube boilers with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, water-supply and -return connections, and controls.
- D. Pressure Vessel Design: Straight, steel pipe welded in a concentric pattern to separate flue-gas and heating media to form **[two][four]** passes with welded fins to improve heat transfer in secondary flue-gas passages. Include the following accessories:
1. Handholes for waterside inspections.
 2. Lifting lugs on top of boiler.
 3. Minimum **NPS 1 (DN 25)** hose-end drain valves at water passage low point.
 4. Tappings or flanges for water-supply and -return piping.
 5. Built-in air separator.
 6. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
 7. Tappings for steam supply, makeup, level controls, and chemical treatment.
- E. Combustion Chamber: Equipped with flame retainer to lengthen flame-residence time.
- F. Insulation: Minimum **4-inch- (100-mm-)** thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber.
- G. Flue: Top connection, constructed of **[aluminized][stainless]** steel.
- H. Jacket:
1. Mirror-finish stainless steel with screw-fastened closures.
 2. **[Galvanized sheet][Sheet]** metal, with screw-fastened closures and **[baked-enamel][powder-coated]** protective finish.
 3. Mounting base to secure boiler to concrete base.
- I. Barometric Damper: Galvanized-steel assembly with flue-gas thermometer having a minimum **3-1/2-inch- (89-mm-)** diameter dial.

2.4 FIREBOX BOILERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be**

incorporated into the Work include, but are not limited to, the following]:

1. [Hurst Boiler & Welding Company, Inc.]
2. [L.E.S., Inc.]
3. [Superior Boiler Works, Inc]
4. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Hurst Boiler & Welding Company, Inc.]
2. [L.E.S., Inc.]
3. [Superior Boiler Works, Inc]
4. <Insert manufacturer's name>

C. Description: Factory-fabricated, -assembled, and -tested, firebox boilers with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, water-supply and -return connections, and controls.

D. Pressure Vessel Design: Straight, steel tubes [rolled][or][welded] into steel headers. Three passes with wetback design. Minimum heat-exchanger surface of **5 sq. ft./bhp (2.1 sq. m/10 kW)**. Include the following features and accessories:

1. Tube Size and Thickness: **[Minimum NPS 2 (DN 50), minimum 0.105 inch (2.667 mm) thick]<Insert size and thickness>**.
2. Brass washout plugs.
3. Steel turbulators.
4. Lifting lugs on top of boiler.
5. Minimum **NPS 1 (DN 25)** hose-end drain valves at shell low point.
6. Tappings or flanges for water-supply and -return piping.
7. Built-in air separator.
8. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
9. Tappings for steam supply, makeup, level controls, and chemical treatment.

E. Combustion Chamber: Welded steel, **[waterwall and -floor design][water-leg design with refractory insulation poured in the floor]**. Flame observation port.

F. Insulation:

1. Minimum **2-inch- (50-mm-)** thick, **[foil-backed,]** mineral-fiber insulation surrounding the boiler shell.
2. Insulated removable smoke boxes and reversing chamber cover.

G. Flue: Steel, **[top][or][rear]**.

H. Jacket: Sheet metal, with screw-fastened closures and **[baked-enamel][powder-coated]** protective finish.

I. Barometric Damper: Galvanized-steel assembly with flue-gas thermometer having a minimum **3-1/2-inch- (89-mm-)** diameter dial.

2.5 BURNER

A. Burner designed to fire **[gas][oil][combination gas and oil]**. **[Single burner shall be used for dual**

fuels.]

- B. Welded construction with multivane, stainless steel, flame-retention diffuser.
- C. Single-tip retractable nozzle for low-pressure air-atomizing burner.
- D. Mount burner **[on hinged front access door]** to permit unrestricted access to combustion chamber.
- E. Burner Operation: **[On/off][Low-high fire][or][full modulating]** control to return to low-fire position for ignition.
 - 1. Gas-Fired Burner: **[4 to 1][8 to 1][10 to 1]<Insert value>** turndown.
 - 2. Oil-Fired Burner: **[4 to 1][8 to 1]<Insert value>** turndown.
 - 3. Combination Gas- and Oil-Fired Burner: **[4 to 1][8 to 1]<Insert value>** turndown.
 - 4. A lesser turndown shall be considered if published factory performance testing shows no loss in operating performance and no negative impact on service life and maintenance while operating throughout full range of system operating conditions encountered.
- F. Burner Fuel Combustion Efficiency: Minimum **[99.9]<Insert number>** percent.
- G. Gas Pilot: Premix type with automatic electric ignition, complete with electronic flame scanner to monitor the pilot, so primary fuel valve cannot open until pilot flame has been established.
- H. Oil Pilot: **[Intermittent][Interrupted]**-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with **[cadmium sulfide][UV scanner]** flame-safety control.
- I. Manual adjustments not required to operate at varying loads.
- J. Performance shall be repeatable after changes in firing rate.
- K. Control devices and sequence shall comply with **[ASME CSD-1][NFPA 85][FM Global][Industrial Risk Insurers (IRI)][and][or][UL]** requirements.
- L. Damper: Designed to provide accurate control of combustion air with minimum hysteresis. Damper shall close when boiler is off.

2.6 BLOWER

- A. Combustion air supplied by a forced-draft blower assembly that is isolated to reduce vibration and noise.
- B. Mount blower **[integral to burner][or][on hinged front access door]** to permit unrestricted access to combustion chamber.
- C. Centrifugal type, with a forward-curve, backward-inclined airfoil or radial blade wheel.
- D. Blower and drive assembly shall be controlled through boiler's integral controls in response boiler manufacturer's prescribed sequence of operation that is coordinated with burner and fuel train to achieve performance indicated.
 - 1. Where indicated or required to achieve performance, provide blower with unit-mounted variable-frequency controller to vary blower speed in response to prescribed control set point and changes in operating conditions.
 - 2. Variable-speed fan operation shall be checked for resonant frequencies and adjusted to provide

no resonant frequencies throughout entire operating range.

E. Blower Drive Assembly: **[Belt][or][direct]** drive.

1. Belts: Multiple matching belts that are oil resistant, non-static conducting and sized for a **[2.0]<Insert value>** service factor.
2. Belt Guards: Easily removable guard that encloses drive.

F. Blower Motor:

1. General Requirements: Comply with requirements for motors specified in Section 230500 "Common Work Results for HVAC" unless more stringent requirements are indicated below:
 - a. Efficiency: **[Premium efficient]<Insert requirement>**.
 - b. Enclosure: **[Open dripproof][Totally enclosed][or][totally enclosed, fan cooled]**.
 - c. Insulation Class: **[F][H]<Insert requirement>**.
 - d. Service Factor: **[1.15]<Insert value>**.
 - e. Motors operated through variable-frequency controllers shall be inverter duty rated according to NEMA MG-1.
2. Motor Sizes: Minimum size as indicated and large enough so driven load does not require motor to operate in service factor.

2.7 GAS TRAIN

A. Comply with Owner insurance underwriter requirements. In absence of specific requirements, comply with more stringent requirements indicated.

B. Pilot gas piping train shall include:

1. One manually operated, lubricated plug cock or ball valve upstream of all valves and accessories.
2. One pressure regulator with vent.
3. Pressure gage located downstream of pressure regulator. Nominal **[2-inch (50-mm)][4-inch (100-mm)]<Insert size>** diameter face with graduated scale to indicate gas pressure. Gage shall have normal operating pressure of about **[50]<Insert number>** percent of full range.
4. Primary and secondary automatic valves to operate simultaneously.
5. Normally open, full port electrically operated valve in a vent pipe connected between automatic valves.
6. Manually operated valve with threaded plug located downstream of both automatic gas valves to permit leakage testing.
7. **<Insert feature>**.

C. Main gas piping train shall include:

1. Threaded pressure tapping with threaded plug upstream and downstream of valve and regulator.
2. One manually operated, lubricated plug cock, ball valve, or butterfly valve upstream and downstream of all valves and accessories.
3. One main pressure regulator with vent.
4. Primary and secondary automatic valves to operate simultaneously.
5. Manually operated gas valve with threaded plug located downstream of both automatic gas valves to permit leakage testing.
6. Normally open, full port electrically operated valve in a vent pipe connected between automatic valves.
7. Pressure gage with isolation valve located upstream and downstream of pressure regulator and

- at inlet to burner. Nominal [2-inch (50-mm)]<Insert size> diameter face with graduated scale to indicate gas pressure. Gage shall have normal operating pressure of about [50]<Insert value> percent of full range.
8. Proof of closure switch for each motor-operated valve and pressure regulator.
 9. Low-gas-pressure and high-gas-pressure switch.
 10. <Insert feature>.
- D. Control devices and sequence shall comply with [ASME CSD-1][NFPA 85][FM Global][Industrial Risk Insurers (IRI)][and][or][UL] requirements.
- E. Main gas valves shall be wired to close automatically in the event of power failure[, low water level,]or any safety shutdown condition.
- F. Mount pilot and main gas trains on side of boiler and support from boiler base.
- 2.8 OIL TRAIN
- A. Comply with Owner insurance underwriter requirements. In absence of specific requirements, comply with more stringent requirements indicated.
- B. Control devices and sequence shall comply with [ASME CSD-1][NFPA 85][FM Global][Industrial Risk Insurers (IRI)][and][or][UL] requirements.
- C. Oil Pump:
1. Gear-type oil pump, factory [mounted][furnished and shipped loose for field installation].
 2. [Single-][or][Two-] stage pump capable of producing <Insert value> discharge pressure and [15-inch Hg (51-kPa)]<Insert value> vacuum.
 3. Capacity equal to approximately [2]<Insert number> times maximum burner fuel consumption.
 4. Motor shall comply with requirements for motors specified in Section 230500 "Common Work Results for HVAC."
- D. Low-Pressure Air-Atomizing System:
1. Separate air compressor module, factory [mounted][furnished and shipped loose for field installation], with burner-mounted, low-atomizing-air-pressure switch.
 2. Complete system for each burner, furnished by burner manufacturer, including compressor, drive, air filter, after cooler, low-pressure switch, and piping.
 3. Low-air-pressure switch interlocked to prevent burner operation if air pressure failure occurs.
 4. Motor shall comply with requirements for motors specified in Section 230500 "Common Work Results for HVAC."
- E. Oil Burner Piping:
1. Factory-installed fuel oil piping shall include the following:
 - a. Oil-pressure-regulating devices.
 - b. Oil metering controls.
 - c. Low-oil-pressure switch.
 - d. Two motorized oil valves.
 - e. Pressure gauges.
- F. Piping Specialties:
1. Suction-line, manual shutoff valve.



2. Removable-mesh strainer.
3. Oil Filter: Oil filter with permanent edge-type elements that are cleanable by rotation of a handle without interruption to flow.
 - a. Element Spacing: **0.0035 inch (0.1 mm)**.
 - b. Maximum Pressure Loss: **[3 psig (20 kPa)]<Insert value>**.
 - c. Provide with plugged drain.
4. **0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.**
5. **[0- to 300-psig (0- to 2070-kPa)]<Insert pressure>** oil-nozzle pressure gage.
6. Nozzle-line, solenoid-safety-shutoff oil valve.
7. Relief valve located in discharge piping of oil pump with valve discharge connected to oil pump suction piping.

G. Main piping shall include the following (in order, starting at field connection and moving to burner):

1. Manual shutoff valve, first instance.
2. Removable-mesh strainer.
3. Oil filter.
4. Pressure gage with isolation valve, first instance.
5. Pressure regulator.
6. Low-pressure switch.
7. High-pressure switch.
8. Flow meter.
9. Flow control valve.
10. Thermometer.
11. Valved drain.
12. Automatic safety shutoff valve, first instance.
13. Valved leak test, first instance.
14. Automatic safety shutoff valve, second instance.
15. Valved leak test, second instance.
16. Manual shutoff valve, second instance.
17. Pressure gage with isolation valve, second instance.
18. **<Insert component>**.

H. Mount train on side of boiler and support from boiler base.

2.9 FLUE-GAS RECIRCULATION

- A. Equip boiler with packaged flue-gas recirculation system if required to satisfy emission requirements.
- B. Complete package integrating burner, combustion-air blower and damper, fuel train, and controls. Provide interconnecting external ducting if required by manufacturer's design.

2.10 HOT-WATER BOILER TRIM

- A. Include devices sized to comply with **[ASME B31.1][ASME B31.9]**.
- B. Water Temperature Controllers: Operating[, **firing rate**,] and high limit.
- C. Safety Relief Valve: ASME rated.

- D. Pressure and Temperature Gage: Minimum [3-1/2-inch- (89-mm-)]<Insert size> diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about [50]<Insert number> percent of full range.
- E. Boiler Air Vent: **[Automatic][Manual]**.
- F. Drain Valve: Minimum **[NPS 3/4 (DN 20)]<Insert size>** hose-end valve with threaded cap and chain.

2.11 STEAM BOILER TRIM

- A. Include devices sized to comply with **[ASME B31.1][ASME B31.9]**.
- B. Pressure Controllers: Operating[, **firing rate,**] and high limit.
- C. Safety Relief Valve:
 - 1. Size and Capacity: As required for equipment according to 2010 ASME Boiler and Pressure Vessel Code.
 - 2. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
 - a. Drip-Pan Elbow: Cast iron and having flanged or threaded inlet and outlet with threads complying with ASME B1.20.1.
 - b. Exhaust Head: Install exhaust head on vent pipe connected to safety relief valve.
- D. Pressure Gage: Nominal **[4-inch (100-mm)][6-inch (150-mm)][8-inch (200-mm)]<Insert size>** diameter face with graduated scale and siphon, with isolation valve to indicate pressure vessel steam pressure. Gage shall have boiler normal operating pressure of about [50]<Insert number> percent of full range and an accuracy of **[0.5][1]<Insert number>** percent.
- E. Bimetal Thermometer: Stainless steel case with angle position adjustment and nominal **[5-inch (125-mm)]<Insert size>** diameter face having a graduated scale with a range of approximately **[1.5]<Insert number>** times the outlet temperature. Mount thermometer in a Type 316 stainless steel thermowell to indicate steam temperature inside pressure vessel.
- F. Water Column: Minimum **[12-inch (300-mm)]<Insert size>****[reflex]** glass gage with gage rods to protect glass, ball check and shutoff cocks, water column blowdown valves, and vacuum breaker. Midpoint of gage shall be at normal operating water level.
- G. Bottom Blowdown Valves: Factory-installed, duty-rated, slow-acting blowdown valves and interconnecting piping same size as boiler nozzle. **[Blowdown valves shall be combination of slow and quick acting as required by ASME B31.1.]**
- H. Surface Blowdown Valves: Factory-installed, duty-rated isolation valves and interconnecting piping. **[In addition, provide electrically operated control valve, duty rated, to control total dissolved solids (TDS) through boiler controls.]**
- I. Stop Valves: Boiler outlets, except safety relief valves, shall be equipped with duty-rated stop valve in an accessible location as near as is practical to boiler nozzle and same size or larger than nozzle. Valves larger than **NPS 2 (DN 50)** shall have rising stem.
- J. Stop-Check Valves: Factory-installed, duty-rated stop-check valve and stop valve at boiler outlet with free-blow drain valve field installed between the two valves and visible when operating stop-check valve.

K. Feedwater Valves:

1. Factory-installed, duty-rated stop and check valves and interconnecting piping. Stop valves larger than **NPS 2 (DN 50)** shall have rising stem.
2. Factory-installed, three-valve bypass arrangement with modulating control valve positioned between duty-rated stop valves, bypass piping with throttling valve, check valve, and interconnecting piping. Stop and throttling valves larger than **NPS 2 (DN 50)** shall have rising stem. Modulating control valve shall have the following features and characteristics:
3. Duty rated with electric operator to control water level through boiler controls.
4. Equal percentage flow characteristic.
5. Valve Flow: **[Indicated on Drawings][1.25 times boiler output]<Insert requirements>**.
6. Valve Pressure and Temperature Rating: Equal to boiler.
7. Shut-off Leakage: **[0.0001]<Insert number>** percent of valve coefficient.

L. Chemical Injection Assembly: Factory-installed, duty-rated injection quill with ball check valve and isolation valve compatible with dispensed chemical.**M. Sample Cooler:** Factory **[installed][or][furnished for field installation]**, with **[needle]** valve for each connection. **[Constructed of Type 316 stainless steel.]****2.12 CONTROLS****A. Boiler operating controls shall include the following devices and features:**

1. Control transformer(s) with fuse protection, as required by manufacturer, to implement requirements indicated. Provide transformer with 25 percent spare capacity.
2. Set-Point Adjust: Operating and alarm set points shall be field adjustable.

B. Pressure Control for Steam Boilers:

1. Operating-Pressure Control: Factory wired and mounted to control boiler to maintain boiler at constant pressure within **[2]<Insert number>** percent of set point.
2. High-Pressure Cutoff with Automatic Reset: Control stops burner if operating conditions rise above normal operating-pressure set point. Set point shall be adjustable.
3. High-Pressure Cutoff with Manual Reset: Control stops burner operation upon reaching adjustable high limit set point that is below safety valve setting.

C. Water-Level Control for Steam Boilers:

1. Operating Water-Level Control:
 - a. Cycle feedwater pump(s) for water-level control.
 - b. Operate feedwater pump(s) continuously and modulate boiler feedwater valve in response to **[water level][steam flow rate and rate of pressure change][water level, steam flow rate, and rate of pressure change]** for water-level control.
2. Low-Water Cutoff Switch: **[Electronic][Float and electronic]** probe shall prevent burner operation on low water. Cutoff switch shall be **[manual][automatic]**-reset type.
3. Auxiliary Low-Water Cutoff Switch: **[Electronic][Float and electronic]** probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
4. Microprocessor-based control.
5. Accuracy within **[0.01 inch (0.25 mm)]<Insert value>**.
6. Visual indication of level, alarms, and errors through alphanumeric display.
7. Features:

- a. Continuous water-level indication.
 - b. Low-water cutoff and alarm.
 - c. High-water alarm.
 - d. Low- and high-water warning.
 - e. Control of feedwater pump.
 - f. Control of modulating feedwater control valve.
 - g. Continuous monitoring of float operation.
 - h. Column blowdown detection and reminder.
 - i. Auxiliary low-water cutoff check.
 - j. Auto and manual reset.
 - k. Alarm annunciation.
 - l. **<Insert feature>**.
- D. Operating Controls for Hot-Water Boilers:
 1. Sequence of Operation:
 - a. Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outdoor-air temperature. At **[0 deg F (minus 17 deg C)]<Insert temperature>** outdoor-air temperature, set supply-water temperature at **[200 deg F (93 deg C)]<Insert temperature>**; at **[60 deg F (15 deg C)]<Insert temperature>** outdoor-air temperature, set supply-water temperature at **[140 deg F (60 deg C)]<Insert temperature>**.
 - b. Indicated on Drawings.
 - c. **<Insert requirements>**.
- E. Multiple Boiler Operation: Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
- F. Boiler Emergency Shutdown: Interlock with field-installed boiler emergency shutdown switch to shut down boiler when activated. Manufacturer to furnish break-glass-type switch with permanent nameplate titled "Boiler Emergency Shutdown" for field installation.
- G. Chemical Feed System Interface: Dry contacts to interface control and operation of chemical feed pump.
- H. Burner Safety Controls for Steam Boilers: To maintain safe operating conditions, burner safety controls limit burner operation.
 1. High Cutoff: **[Automatic][and][Manual]** reset stops burner if operating conditions rise above maximum boiler operating pressure.
 2. Low-Water Cutoff Switch: Float and electronic probe shall prevent burner operation on low water. Cutoff switch shall be automatic-reset type.
 3. Auxiliary Low-Water Cutoff Switch: Float and electronic probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
 4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
- I. Burner Safety Controls for Hot-Water Boilers: To maintain safe operating conditions, burner safety controls limit burner operation.
 1. High Cutoff: **[Automatic][and][Manual]** reset stops burner if operating conditions rise above boiler design temperature.
 2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be **[manual][automatic]**-reset type.
 3. Auxiliary Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low-water

- alarm limit. Cutoff switch shall be manual-reset type.
- 4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

J. Burner Flame Safeguard Controls:

- 1. Factory equipped with flame safeguard control and infrared flame scanner.
- 2. Microprocessor-based, solid-state control having sequence and flame-on visual indication and fault code indications of flame safeguard trip functions.
- 3. Control shall include dynamic self-check logic.
- 4. Control shall have a fixed operating sequence incapable of being manually altered that includes start, prepurge, pilot and main fuel ignition run, and postpurge cycles.
- 5. Control shall be nonrecycle type for maximum safety that shall shut down the burner and indicate, as a minimum, the following trip functions:
 - a. Pilot and main flame failure.
 - b. High- and low-fire proving switch faults.
 - c. Running interlocks open.
 - d. False flame signal and fuel valve open.
- 6. Control shall include a run/test switch to allow interruptions to sequence just after prepurge and during pilot ignition trial, and run cycles for adjustments to firing rate motor, damper linkages, and pilot flame for minimum turndown tests.

K. Combustion-Air Controls: Factory equipped with motor-operated combustion-air damper and blower control to regulate burner fire according to load demand.

L. Oxygen Trim Control:

- 1. Provide oxygen trim system to continuously monitor and display oxygen concentrations in boiler flue gas and adjust fuel and airflow to maintain an adjustable oxygen-level set point.
- 2. System shall compensate for changes in ambient temperature, barometric pressure, humidity, and variations in fuel characteristics.

M. Surface Blowdown Control: Provide a conductivity sensor and control circuitry to operate an automatic control valve in surface blowdown piping to maintain total dissolved solids (TDS) within boiler manufacturer's prescribed level.

N. DDC System Interface: Factory install hardware and software to enable system to monitor, control, and display boiler status and alarms.

- 1. Hardwired I/O Points:
 - a. Monitoring: On/off status, **[common trouble alarm][low-water-level alarm]<Insert monitoring points>**.
 - b. Control: On/off operation, **[hot-water-supply temperature set-point adjustment][steam pressure adjustment]<Insert control points>**.
- 2. Communication Interface: **[ASHRAE 135 (BACnet)][(LonTalk)][Modbus][Industry-accepted, open-protocol]<Insert type of interface>** communication interface shall enable control system operator to remotely control on/off and capacity of boiler and monitor the boiler operation from an operator workstation. Control features are available, and monitoring points are displayed locally at boiler-control panel through the interface.

O. Integrated Boiler-Control System:

1. Integral control of burner management for flame safety, boiler modulation, and operator interface functions with features and functions indicated.
 2. Factory preconfigured.
 3. Utilizing solid-state controls and sensors to provide various control functions, including the following:
 - a. Automatic sequencing of the boiler through standby, prepurge, pilot flame establishing period, main flame establishing period, run, flame proving and lockout, and postpurge.
 - b. Full modulating control of air and fuel through Proportional-Integral-Derivative (PID) algorithm.
 - c. Thermal shock protection.
 - d. High and low limit alarms and shutdowns.
 4. Local operator interface through nominal [10-inch (250-mm)]<Insert size> color touch screen graphical display for setup, monitoring, and data acquisition.
 - a. Manual control of the boiler firing rate using control screens to increment or decrement firing rate.
 - b. Indication of burner management controller status and diagnostics.
 - c. Display of system alarms and faults.
 - d. Display of history of alarms and faults.
 - e. Display of recommendations for troubleshooting of fault conditions.
 - f. Display of water-level indication and alarm(s).
 - g. Stack flue-gas, combustion-air, and shell water-temperature indication.
 - h. Boiler efficiency calculation and display.
 - i. Low-fire hold with minimum temperature control.
 - j. Assured low-fire cutoff (ALFCO).
 - k. High stack temperature annunciation with auto cutoff.
 - l. Audible alarm and silencing through touch screen intervention.
 5. Fully integrated control of the following:
 - a. Blower operation and combustion-air damper for varying operating conditions.
 - b. Oxygen trim and monitoring to compensate for combustion-air variations.
 - c. Parallel positioning for independent fuel and air control for enhanced fuel efficiency.
 - d. Multiple boiler lead/lag control with hot standby.
 - e. Draft control for maintaining proper and consistent draft for enhanced fuel efficiency.
 - f. <Insert additional features>.
 6. E-mail and paging feature to multiple contacts via Internet and phone line independent of control system interface.
 7. LAN/WAN interface with remote monitoring software to allow remote monitoring independent of control system interface.
- P. Control Enclosures:
1. NEMA 250, Type [1][4][4X][12]<Insert type>.
 - a. Provide enclosure with integral vents, fans, heater, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
 2. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
 3. Mounted on boiler assembly at a location convenient to operator.
 4. Provide hinged full-size door with key lock. Provide common key for all locks.



5. Enclosure shall consist of multiple sections divided by a partition with a separate hinged door for each section. One section shall house low-voltage controls and other section shall house line voltage controls.
 6. Enclosure shall house the following:
 - a. Control transformers with fuses.
 - b. Labeled terminal strips.
 - c. Controller(s) to provide control and alarm functions indicated.
 - d. Audible indication of safety alarms.
 7. Face of enclosure shall provide the following:
 - a. Visual indication of operating components and alarms.
 - b. Auto/local capability to allow operator to manually operate boiler locally.
 - c. Audible alarm-silence capability.
 - d. Labels for switches, lights, and displays to provide clear indication of service.
- Q. Control Instrument Enclosures: Control instruments and devices that are mounted on the boiler assembly and cannot be installed inside the control enclosure shall have same or higher level of protection indicated for control enclosures.
- R. Control Cable and Wire:
1. Control cable and wiring shall be numbered and color-coded to match wiring diagram.
 2. Install cable and wiring located outside of enclosure(s) in a[**metal**] raceway. Use flexible conduit to make final terminations. Provide watertight installation for applications exposed to moisture.

2.13 ELECTRICAL POWER

- A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
1. Enclosure: NEMA 250, Type [1][4][4X][12]<Insert type>.
 - a. Enclosure shall have integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
 - b. Mounted on boiler assembly at a location convenient to operator.
 - c. Enclosure shall have hinged full-size door with key lock with common key for all locks.
 2. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
 3. Install wiring outside of an enclosure in a [metal] raceway. Make final connections to motors using flexible conduit. Provide watertight installation for applications exposed to moisture.
 4. Field power interface shall be to [fused disconnect switch][nonfused disconnect switch][circuit breaker]. Withstanding rating of disconnecting means shall protect equipment. Coordinate requirements with field electrical power source.
 5. Provide branch power circuit to each motor and to controls[**with a disconnect switch or circuit breaker**].
 6. Provide each motor with NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
 7. Provide transformer with fuses and power wiring to power a 20-A 120-V duplex receptacle

mounted in each boiler control panel for use in connecting analytical and testing equipment.

2.14 FINISH

A. General:

1. Paint boiler, using manufacturer's standard procedures, except comply with requirements indicated.
2. Miscellaneous surfaces shall be finished to match continuous surfaces.
3. Manufacturer shall field touch up or entirely repaint surface finishes, which were damaged during shipment, to original condition, using original materials and methods.
4. Paint shall be suitable for temperatures encountered on painted surfaces.
5. Requirements indicate minimum quality level. Provide more robust paint system if required to comply with other requirements indicated.

B. Preparation:

1. Follow paint manufacturer's published preparation and application instructions.
2. When paint manufacturer's recommended preparation requirements differ from those specified, use more stringent requirements.
3. Structural steel with visible corrosion shall be sandblasted according to SSPC SP-6 or SSPC SP-10 before applying primer and paint.
4. Before application of a primer and a top coat, remove oil and grease from surfaces to be coated using clean rags soaked in thinner according to SSPC SP-1.
5. Treat galvanized-steel surfaces that cannot be procured with a phosphatized finish with a phosphate rinse to ensure proper paint adhesion.

C. Primer:

1. Rust-inhibiting type with a minimum dry film thickness of **[2 mils (0.05 mm)]<Insert thickness>**.
2. Provide multiple passes if required to prevent runs.
3. Select a primer that is compatible with substrate and finish coat.

D. Finish Coat:

1. Finish coat shall be **[alkyd enamel][epoxy][polyurethane]<Insert type>**.
2. Use dry film thickness recommended by paint manufacturer, but not less than **[2 mils (0.05 mm)]<Insert thickness>**. Provide multiple passes if required to prevent runs.

E. Paint the following surfaces with both a primer and finish coat:

1. Base and miscellaneous supports that are not hot dip galvanized.
2. Carbon steel that is not galvanized.
3. Exterior surfaces of unit exposed to view.
4. Piping and trim.

F. Do not paint aluminum or stainless steel.

2.15 FLUE-GAS ECONOMIZER

- A. Where indicated, provide heat exchanger to transfer heat from boiler flue gas to boiler feedwater.
- B. Type: Rectangular configuration with replaceable finned tubes, arranged for up-flow flue gas and

parallel flow water.

- C. Internal Bypass: Economizer furnished with an internal bypass diverter to provide emergency bypass operation, with no external ducting, for controlling the following:
1. Stack corrosion.
 2. Turndown performance.
 3. Excessive flue-gas backpressure due to fouling.
- D. Construction:
1. Comply with 2010 ASME Boiler and Pressure Vessel Code.
 2. Design for abnormal operation with no water in tubes at temperature indicated.
 3. Design Pressure:
 - a. Water Tubes: **[300 psig (2050 kPa)]<Insert value>**.
 - b. Inner Casing: **[10 inches wc (2500 Pa)]<Insert value>**.
 - c. Design Temperature: **[700 deg F (370 deg C)]<Insert value>**.
 4. Tubes and Headers:
 - a. ASTM A254, Type 316 stainless steel.
 - b. Helically wound, nonserrated stainless steel fins continuously welded to tubes.
 - c. Arrange tubes to permit cleaning by soot blowing.
 - d. Fin Density: **[48 fins per foot (157 fins per meter)]<Insert value>**.
 - e. Fin Height: **[0.5 inch (13 mm)]<Insert value>**.
 - f. Return bend areas shall be exposed to the bulk temperature of the flue gas.
 - g. Headers shall be external to the casing.
 - h. Flanged piping connections.
 - i. Drainable by gravity.
 5. Casing:
 - a. Double wall, with **[hinged][or][removable]** panels and insulation between inner and outer casing. Access panels shall allow access to tubes and internal bypass diverter for cleaning and replacement.
 - b. Casing shall be gas tight.
 - c. Inner Casing: Stainless steel, all welded.
 - d. Insulation: Mineral fiber, **[2 inch (50 mm)]<Insert value>** thick.
 - e. Outer Casing: Galvanized, stainless or painted carbon steel.
 - f. Angle flanges on flue-gas inlet and outlet for attachment of breeching and stack.
- E. Accessories:
1. Inlet and Outlet Transitions: Designed by economizer manufacturer and furnished with economizer.
 2. Safety Relief Valve: Selected by economizer manufacturer according to 2010 ASME Boiler and Pressure Vessel Code requirements.
 3. Soot Blowers: Steam-operated, rotating valve-in-head. Provide sufficient number to clean all tube areas. Location, arrangement, and quantity based on recommendations of soot blower manufacturer for type and size of economizer furnished.
 4. Thermometers:
 - a. Water Inlet and Discharge Thermometers: Bimetal thermometer in a stainless steel case with angle position adjustment, nominal **[5-inch (120-mm)]<Insert size>** diameter face

having graduated scale and range of approximately [1.5]<Insert number> times the discharge temperature. Mount thermometer in a Type 316 stainless steel thermowell that is located in a visible location to indicate water inlet and discharge temperature.

- b. Flue-Gas Inlet and Discharge Thermometers: Bimetal thermometer in a stainless steel case with angle position adjustment, nominal [5-inch (120-mm)]<Insert size> diameter face having graduated scale and range of approximately [1.5]<Insert number> times the inlet temperature. Mount thermometer in a Type 316 stainless steel thermowell that is located in a visible location to indicate flue-gas inlet and discharge temperature.

F. Factory Test and Inspections:

1. Inspect completed economizer assembly according to 2010 ASME Boiler and Pressure Vessel Code.
2. Certify inspection and submit completed ASME form for each economizer.

2.16 CAPACITIES AND CHARACTERISTICS

- A. Heating Medium: [Hot water][Steam].
- B. Design Pressure Rating, Hot-Water Boilers: [30 psig (207 kPa)][60 psig (420 kPa)][100 psig (690 kPa)][125 psig (860 kPa)][140 psig (966 kPa)][160 psig (1100 kPa)]<Insert value>.
- C. Design Pressure Rating, Steam Boilers: [15 psig (104 kPa)][150 psig (1035 kPa)][200 psig (1380 kPa)][250 psig (1725 kPa)][300 psig (2070 kPa)]<Insert value>.
- D. Safety Relief Valve Setting: <Insert psig (kPa)>.
- E. Entering-Water Temperature: <Insert deg F (deg C)>.
- F. Leaving-Water Temperature: <Insert deg F (deg C)>.
- G. Design Water-Flow Rate: <Insert gpm (L/s)>.
- H. Design Pressure Drop: <Insert psig (kPa)>.
- I. Steam Operating Pressure: <Insert psig (kPa)>.
- J. Steam-Flow Rate: <Insert lb/h (kg/s)>.
- K. Fuel-to-Steam Efficiency: <Insert number> percent.
- L. Fuel-to-Water Efficiency: <Insert number> percent.
- M. Number of Passes: [One][Two][Three][or][Four]<Insert number>.
- N. Gas Input: <Insert MBh (kW)>.
- O. Gas Input Flow: <Insert cfh (mL/s)>.
- P. Gas Pressure: <Insert psig (kPa)>.
- Q. Oil Input: <Insert MBh (kW)>.
- R. Oil Input Flow: <Insert gph (mL/s)>.

- S. Output Capacity: **<Insert MBh (kW)>**.
- T. Flue-Gas Economizer:
 - 1. Design Feedwater Flow: **<Insert gpm (L/s)>**.
 - 2. Design Feedwater Pressure Drop: **<Insert psig (kPa)>**.
 - 3. Entering-Feedwater Temperature: **<Insert deg F (deg C)>**.
 - 4. Leaving-Feedwater Temperature: **<Insert deg F (deg C)>**.
 - 5. Design Flue-Gas Flow: **<Insert cfm (L/s)>**.
 - 6. Design Flue-Gas Pressure Drop: **<Insert inches wc (Pa)>**.
 - 7. Entering-Flue-Gas Temperature: **<Insert deg F (deg C)>**.
 - 8. Leaving-Flue-Gas Temperature: **<Insert deg F (deg C)>**.
- U. Burner Blower:
 - 1. Motor Horsepower: **<Insert number>** hp.
- V. Electrical Characteristics:
 - 1. Volts: **[115][208][230][460]<Insert number>** V.
 - 2. Phase: **[Single][Three]**.
 - 3. Hertz: **[50][60]<Insert number>** Hz.
 - 4. Full-Load Amperes: **<Insert number>** A.
 - 5. Minimum Circuit Ampacity: **<Insert number>** A.
 - 6. Maximum Overcurrent Protection: **<Insert number>** A.
- W. Sound (decibels, A weighted): **<Insert number>** dB.

2.17 SOURCE QUALITY CONTROL

- A. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.
- B. Burner and Hydrostatic Test:
 - 1. Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve performance requirements indicated.
 - 2. Perform hydrostatic test of pressure vessel, piping, and trim of assembled boiler.
- C. Witness Testing:
 - 1. Allow Owner access to witness source quality-control testing of boilers.
 - 2. Notify **[Architect][Owner][15]<Insert number>** days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and flue; piping; controls; and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for flue, piping, controls, and electrical connections.
- B. Examine areas where boilers will be installed for suitable conditions.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

- A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- B. Equipment Mounting:
 1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install gas-fired boilers according to NFPA 54.
- D. Install oil-fired boilers according to NFPA 31.
- E. Assemble and install boiler trim, components, and accessories that are not factory installed.
- F. Install control and electrical devices furnished with boiler that are not factory mounted.
- G. Install control and power wiring to field-mounted control and electrical devices furnished with boiler that are not factory installed.
- H. Perform boil-out and cleaning procedures according to manufacturer's written instructions after completion of hydrostatic testing and before performing other field tests. [**Boiler manufacturer's factory-authorized representative shall witness boil-out and cleaning procedures.**] Following boil-out and cleaning procedures, boiler shall be washed and flushed until water leaving boiler is clear.
- I. Protect boiler fireside and waterside from corrosion.
 1. Before boiler is filled with water, protect by dry storage method recommended by boiler manufacturer.
 2. After boiler is filled with water, and left not fired for more than [10]<Insert number> days, protect by wet storage method recommended by boiler manufacturer.
 3. Chemical Treatment: Quality of water in boilers shall be maintained by a professional water-treatment organization that shall provide on-site supervision to maintain the required water quality during periods of boiler storage as well as during operating, standby, and test conditions. Refer to <Insert applicable Section number and title> for additional requirements.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.



- B. Where installing piping adjacent to boiler(s), allow space for service and maintenance.
- C. Connect gas piping to boiler gas-train inlet with dirt leg, shutoff valve, and union or flange. Piping shall be at least full size of gas-train connection. Provide a reducer if required.
- D. Connect oil piping to oil-train connection with dirt leg, shutoff valve, and union. Piping shall be at least full size of oil-train connection. Provide a reducer if required. Provide drain valve with threaded plug at piping low point.
- E. Connect hot-water piping to supply- and return-boiler tapplings with shutoff valve and union or flange at each connection.
- F. Connect steam and condensate piping to supply-, return-, and blowdown-boiler connections with union or flange at each connection. Provide each connection with shutoff valve if shutoff valves are not factory furnished with boiler trim. **[Provide check valves in blowdown piping of each boiler that connects multiple boilers.]**
- G. Connect feedwater piping to inlet- and discharge-flue-gas economizer connections with union or flange at each connection. Provide each connection with shutoff valve and other accessories indicated and recommended by manufacturer.
- H. Install piping from safety relief valves to nearest floor drain.
- I. Install piping from safety valves and drip-pan elbows. Extend piping from safety valves and terminate to vent outdoors. Extend piping from drip-pan elbow drain to nearest floor drain.
- J. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
- K. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.
 - 1. Provide a temperature-controlled nonpotable domestic cold water source to cool hot equipment drains to deliver a discharge temperature of **<Insert temperature>**.
- L. Connect chemical-treatment piping to each boiler chemical-treatment connection with check valve and isolation valve.

3.4 FLUE CONNECTIONS

- A. Connect breeching to full size of boiler outlet. Comply with requirements in **[Section 235116 "Fabricated Breechings and Accessories"]** and **[Section 235133 "Insulated Sectional Chimneys"]** for venting materials.
- B. Install flue-gas recirculation duct from vent to burner if not factory furnished and installed. Comply with requirements in Section 235116 "Fabricated Breechings and Accessories" for recirculation duct materials.
- C. Install easily accessible test ports for field testing of flue gas from each boiler.
- D. Install flue-gas economizer with factory-furnished transitions to connect to boiler and to field-installed breeching.

3.5 ELECTRICAL POWER CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between boilers and other equipment to interlock operation as required, to provide a complete and functioning system.
- C. Connect control wiring between boiler control interface and **[DDC control system]<Insert system description>** for remote monitoring and control of boilers. Comply with requirements in **[Section 230923 "Direct Digital Control (DDC) System for HVAC."]<Insert Section number and title.>**

3.7 NETWORK AND PHONE CONNECTIONS

- A. Connect LAN/WAN network cable to boiler controls to provide connectivity for remote monitoring through integrated boiler control system.
- B. Connect phone system cable to boiler controls to provide connectivity for remote monitoring and alarm notification through integrated boiler control system.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Hydrostatic Leak Test: Repair leaks and retest until no leaks exist.
 - 3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
 - b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and **[water temperature][steam pressure]**.
 - c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Boiler will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

- F. Occupancy Adjustments: When requested within **[12 months of date of Substantial Completion]<Insert time period>**, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.
- G. Performance Tests:
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 2. Boilers shall comply with performance requirements indicated, as determined by field-performance tests. Adjust, modify, or replace equipment in order to comply.
 3. Perform field-performance tests to determine the capacity and efficiency of boilers.
 - a. For dual-fuel boilers, perform tests for each fuel.
 - b. Test for full capacity.
 - c. Test for boiler efficiency at **[low fire, 10, 20, 30, 40, 50, 60, 70, 80, 90, and high fire (100)]<Insert range>** percent of full capacity. Determine and document efficiency at each test point.
 - d. For boilers equipped with flue-gas economizers, perform tests with and without flue-gas economizer operating.
 4. Test each safety valve. Record pressure at valve blowdown and reset. Test valve(s) with boiler operating at full capacity to ensure valve has capacity to prevent further rise in pressure.
 5. For boilers equipped with automatic oxygen trim control, conduct tests with automatic oxygen trim control on manual at zero trim and record performance. Repeat tests with automatic oxygen trim control under automatic control and record performance.
 6. Repeat tests until results comply with requirements indicated.
 7. Provide measurement and analysis equipment required to determine performance.
 8. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
 9. Notify **[Architect][Owner][20]<Insert number>** days in advance of test dates.
 10. Document test results in a report and submit with informational submittals.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain boilers. **[Video training sessions and provide electronic copy of video to Owner.]** Refer to Section 017900 "Demonstration and Training."

END OF SECTION 23 52 39 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 52 39 13	23 52 39 00	Fire-Tube Boilers



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 53 13 00 - BOILER FEEDWATER PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Feedwater units.
2. Feedwater unit with vacuum producer.

1.2 DEFINITIONS

- A. NPSHR:** Net-positive suction head required.

1.3 ACTION SUBMITTALS

A. Product Data: For each unit to include the following:

1. Equipment performance and operating characteristics, such as rated makeup water, feedwater, steam condensate, and steam flow rates; working pressure; tank capacities; temperature and NPSHR; and pump performance curves with selection points clearly indicated.
2. Furnished specialties and accessories.
3. Construction details, material descriptions, dimensions and weight of individual components, and profiles and finishes.
4. Force and moment capacity of each field piping connection.
5. Dimensioned location of low, high, and normal water level showing operating set point and each alarm set point.
6. Temperature and pressure rating, size, and materials of construction for trim components including piping, fittings, flanges, unions, and valves. Provide valve manufacturer Product Data for each valve furnished. For safety valves, include trip and reset settings and flow capacity.
7. Manufacturer Product Data showing size, scale range, and accuracy of thermometers and pressure gages.
8. Detailed information of controls including Product Data with technical performance, operating characteristics, and sequence of operation.
9. Product Data for each motor, including performance, operating characteristics, and materials of construction.

B. Shop Drawings:

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring. Differentiate between factory and field installation.
4. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

C. Delegated Design Submittals: For boiler feedwater pumps.



1. Include design calculations for selecting [**vibration isolators and**] seismic restraints and for designing vibration isolation bases.
2. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan and elevation views, drawn to **<Insert scale>** scale, indicating equipment manufacturer's service clearances, structure and base attachment, piping, power, and controls. Each view to show screened background with the following:
 1. Column grids, beams, columns, and concrete equipment bases.
 2. Room layout with walls, floors, and roofs, including each room name and number.
 3. Equipment and products located in vicinity of boiler feedwater pumps and part of final installation including products of other trades, such as lighting, fire suppression systems, and plumbing systems.
- B. Seismic Qualification Data: Certificates, for feedwater equipment, accessories, and components, from manufacturer.
 1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For feedwater equipment to include in emergency, operation, and maintenance manuals.
- B. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Gaskets: Furnish [**one**]**<Insert number>** replacement gasket(s) for each gasketed opening.
 2. Gage Glass: Furnish [**one**]**<Insert number>** replacement glass(es) for each gage glass.
 3. Pump Mechanical Seal Set: Furnish [**one**]**<Insert number>** replacement mechanical seal set(s) for each unique pump mechanical seal.
 4. **<Insert extra materials>**.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Shipping:

1. Clean flanges and exposed-metal surfaces and treat with anticorrosion compound after assembly and testing.
2. Protect flanges, pipe openings, and nozzles with flange covers or with screwed-in plugs.
3. Ship boiler feedwater pumps from the factory free of water. Drain water and blow pumps dry with compressed air if required to remove all water before shipping.
4. Cover and protect electrical and control devices and open connections.

B. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

C. Comply with manufacturer's written rigging instructions.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design equipment bases, vibration isolation, and seismic restraints for boiler feedwater pumps.

B. Seismic Performance: Boiler feedwater pumps shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.

1. The term "withstand" means "the boiler feedwater pumps will remain in place without separation of any parts when subjected to the seismic forces specified[**and the boiler feedwater pumps will be fully operational after the seismic event**]."
2. Component Importance Factor: **[1.5][1.0]**.
3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

C. ASME Compliance:

1. Fabricate and label unit receivers of boiler feedwater pumps according to ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
2. Factory-installed piping that connects pumps to receivers shall comply with **[ASME B31.1, "Power Piping."][ASME B31.9, "Building Services Piping."]**
3. Safety valves and pressure vessels shall bear the appropriate ASME label.

D. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the state in which equipment was operating immediately before loss of normal power. This shall be accomplished without need for manual intervention by an operator when power is restored either through a backup power source or through normal power if restored before backup power is brought on-line.
2. See Drawings for equipment served by backup power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 FEEDWATER UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. [Alyan Pump Company]
2. [Aurora Pump; Pentair Ltd.]
3. [BFS Industries, LLC]
4. [Bryan Boilers; Bryan Steam LLC]
5. [Cleaver-Brooks]
6. [Deaerating Designs]
7. [Domestic Pump]
8. [Eastern Industrial Products, Inc.]
9. [Flotronics, Inc]
10. [Gerow Equipment Co.]
11. [Industrial Steam]
12. [Lattner Boiler Manufacturing]
13. [Lockwood Products]
14. [MEPCO, LLC.]
15. [Parker Boiler]
16. [Precision Boilers]
17. [PVI; A WATTS Brand]
18. [Roth Pump Company]
19. [Sellers Engineering Co]
20. [Shippensburg Pump Co., Inc]
21. [Skidmore Pump]
22. [Smith-Koch, Inc]
23. [Stickle Steam Specialties Co., Inc.]
24. [Superior Boiler Works, Inc]
25. [York-Shipley Global; Division of Power Mechanical, Inc.]
26. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [Alyan Pump Company]
2. [Aurora Pump; Pentair Ltd.]
3. [BFS Industries, LLC]
4. [Bryan Boilers; Bryan Steam LLC]
5. [Cleaver-Brooks]
6. [Deaerating Designs]
7. [Domestic Pump]
8. [Eastern Industrial Products, Inc.]
9. [Flotronics, Inc]
10. [Gerow Equipment Co.]
11. [Industrial Steam]
12. [Lattner Boiler Manufacturing]
13. [Lockwood Products]
14. [MEPCO, LLC.]
15. [Parker Boiler]
16. [Precision Boilers]
17. [PVI; A WATTS Brand]
18. [Roth Pump Company]
19. [Sellers Engineering Co]

20. [Shippensburg Pump Co., Inc]
21. [Skidmore Pump]
22. [Smith-Koch, Inc]
23. [Stickle Steam Specialties Co., Inc.]
24. [Superior Boiler Works, Inc]
25. [York-Shipley Global; Division of Power Mechanical, Inc.]
26. <Insert manufacturer's name>

C. Description: Factory-assembled and -tested unit consisting of a receiver, feedwater pumps, controls, and the following features and accessories:

1. [Liquid-filled industrial][Bimetal dial-type] thermometer graduated in [Fahrenheit][and][Celsius].
2. Level gage glass[, reflex flat type,] with stops at top and bottom.
3. Lifting eyes.
4. Companion flanges.
5. Pump, suction and discharge isolation valve, inlet strainer, discharge check valve, and liquid-filled pressure gage.
6. Makeup Water Assembly: [Float operated with integral valve][Electric level controller and valve]; with inlet strainer and three-valve bypass.
7. Feedwater Heater: Sparge tube, thermostat, and control valve.
8. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A53/A53M, Type S (seamless), Grade B; or ASTM A106/A106M, Type S, Grade B, [Schedule 40][Schedule 80]; with threaded joints and fittings.
 - a. Cast-Iron Threaded Fittings: ASME B16.4; Class [125][250].
 - b. Malleable-Iron Threaded Fittings: ASME B16.3, Class [150][300].
 - c. Forged-Steel Fittings: ASME B16.11, Class 3000.
 - d. Malleable-Iron Unions: ASME B16.39; Class [150][300].
 - e. Forged-Steel Unions: MSS SP-83, Class 3000.
9. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A53/A53M, Type E (electric-resistance welded), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule [40][80]; with welded joints and carbon-steel fittings and flanges.
 - a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
 - b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class [150][300], including bolts, nuts, and gaskets.
10. Pump-discharge bypass with relief valve or orifice plate sized to provide continuous pump operation with boiler feedwater valve closed.
11. Threaded connection and provision for chemical injection quill.
12. Sample cooler.
13. <Insert accessory>.

D. Receiver:

1. Material: [Close-grain cast iron][Welded carbon steel][Welded carbon steel galvanized after fabrication][Stainless steel].
2. Additional corrosion protection:
 - a. [0.07-inch (1.8-mm)][0.13-inch (3.3-mm)][0.19-inch (4.8-mm)]<Insert dimension> thickness allowance.
 - b. Electrolytic corrosion-inhibitor anode.
3. Finish: [Primer][Primer under enamel topcoat][Primer under epoxy topcoat].



4. Factory-Applied Insulation and Jacket: Minimum thickness of **[2 inches (50 mm)]<Insert dimension>** for mineral-fiber pipe and tank insulation. Cover insulation with **[painted steel][stucco-embossed aluminum][stainless steel]** jacket.
 5. Mounting Arrangement: **[Recessed below floor][Floor mounted]**.
 6. Mounting Frame: Structural-steel stand to support receiver and pumps. **[Fabricate stand with bracing adequate for seismic forces, according to authorities having jurisdiction, and to allow anchoring mounting frame to floor.]**
 7. Drain connection with valve.
- E. Vertical Feedwater Pump: Flange-mounted, close-coupled, **[single-stage,][multistage,]** radially split-case-design centrifugal pump; rated for **[175-psig (1205-kPa)]<Insert value>** minimum working pressure and a continuous water temperature of at least **[225 deg F (107 deg C)]<Insert temperature>**; with the following features:
1. Impeller: **[Bronze][Stainless steel]**.
 2. Seals: Mechanical.
 3. Motor: **[Open dripproof][Totally enclosed][Totally enclosed fan-cooled]** enclosure. Comply with requirements in Section 230500 "Common Work Results for HVAC."
- F. Horizontal Feedwater Pump: Base-mounted, **[single-stage,][multistage,]** radially split-case-design centrifugal pump; rated for **[175-psig (1205-kPa)]<Insert value>** minimum working pressure and a continuous water temperature of at least **[225 deg F (107 deg C)]<Insert temperature>**; with the following features:
1. Impeller: **[Bronze][Stainless steel]**.
 2. Coupling: **[Close][Flexible]**.
 3. Seals: Mechanical.
 4. Motor: **[Open dripproof][Totally enclosed][Totally enclosed fan-cooled]** enclosure. Comply with requirements in Section 230500 "Common Work Results for HVAC."
- G. Control panel shall be unit mounted and factory wired and shall include the following:
1. NEMA 250, **[Type 1][Type 4][Type 4X][Type 12]<Insert type>** enclosure.
 2. Single-point field power interface to **[fused disconnect switch][nonfused disconnect switch][circuit breaker]**. Withstanding rating of disconnecting means shall protect equipment. Coordinate requirements with field electrical power source.
 - a. Branch power circuit to each motor and to controls **[with a disconnect switch or circuit breaker]**.
 3. NEMA-rated motor controller for each motor, and include a hand-off-auto switch and overcurrent protection.
 - a. Alternating controls for multiple-pump units with intermittent operation as indicated by control sequence.
 - b. Provide variable-frequency controller **[with manual bypass]** and line reactors for each variable-speed motor.
 4. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
 5. Wiring outside of an enclosure in a **[metal]** raceway. Make connections to motor with liquidtight conduit.
 6. Removable control mounting plate.
 7. Visual indication of status and alarm **[with momentary test push button]**.
 8. Audible alarm and silence switch.
 9. Visual indication of elapsed run time, graduated in hours.

10. Fused control-circuit transformer.
11. Microprocessor-based controller.

H. Feedwater Single-Pump Control Sequence:

1. Boiler water-level controller starts and stops pump to maintain boiler water-level set point.
2. Visual indication of pump on[**and off**] status.
3. Visual[**and audible**] alarm indication of pump failure.

I. Feedwater Multiple-Pump with Intermittent Operation Control Sequence:

1. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
2. Lead and lag pumps alternate [after each start][to equalize run time].
3. Lead pump failure [automatically starts lag pump if lead pump cannot maintain set point][manually starts lag pump].
4. Visual indication of pump on[**and off**] status.
5. Visual indication of pump lead/lag status.
6. Visual[**and audible**] alarm indication of pump failure.

J. Feedwater Multiple-Pump with Continuous Operation Control Sequence:

1. Pump runs continuously while boiler operates. Electric interlock with boiler control starts lead pump when boiler starts.
2. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
3. Lead and lag pumps alternate [after each start][to equalize run time].
4. Lead pump failure automatically starts lag pump.
5. Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
6. Feedwater pressure controller controls operating feedwater pump(s) speed and starts and stops lag pump(s) to maintain feedwater pressure set point.
7. Visual indication of pump on[**and off**] status.
8. Visual indication of pump lead/lag status.
9. Visual[**and audible**] alarm indication of pump failure.

K. Receiver Makeup Water Control Sequence:

1. Electric level controller operates electric control valve to maintain receiver water-level set point.
2. Mechanical float operates integral valve to maintain water-level set point.
3. Visual[**and audible**] alarm indication of low[**and high**] receiver-water level.

L. Control System Interface: Factory install hardware to enable remote monitoring.

1. Hardwired Monitoring Points: On/off status for each pump[, **failure alarm for each pump**][, **receiver low-water-level alarm**][, **receiver high-water-level alarm**][, **feedwater temperature**]<Insert monitoring>.

M. Capacities and Characteristics:

1. Condensate Receiver:
 - a. Volume: <Insert gal. (L)>.
 - b. Diameter: <Insert inches (mm)>.
 - c. Length: <Insert inches (mm)>.
 - d. Height to Condensate Inlet: <Insert inches (mm)>.
 - e. Condensate Return Minimum Inlet Size: <Insert NPS (DN)>.

- f. Makeup Water Minimum Inlet Size: **<Insert NPS (DN)>**.
 - g. Sparge-Tube Steam Supply: **<Insert lb/h (kW)>**.
2. Feedwater Pumps:
- a. No. of Pumps: **[Simplex][Duplex]<Insert number>**.
 - b. Flow Rate: **<Insert gpm (L/s)>**.
 - c. NPSHR: **<Insert psig (kPa)>**.
 - d. Rated Operating Temperature: **<Insert deg F (deg C)>**.
 - e. Head Pressure: **<Insert psig (kPa)>**.
 - f. Horsepower: **<Insert horsepower>**.
 - g. Speed: **<Insert value> rpm**.
3. Unit Single-Point Power Electrical Characteristics:
- a. Volts: **[208][460]<Insert value> V**.
 - b. Phase: Three.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.3 FEEDWATER UNIT WITH VACUUM PRODUCER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1. **[Alyan Pump Company]**
 - 2. **[Domestic Pump]**
 - 3. **[Flotronics, Inc]**
 - 4. **[Lockwood Products]**
 - 5. **[MEPCO, LLC.]**
 - 6. **[Shippensburg Pump Co., Inc]**
 - 7. **[Skidmore Pump]**
 - 8. **[U.S. Deaerator Co]**
 - 9. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1. **[Alyan Pump Company]**
 - 2. **[Domestic Pump]**
 - 3. **[Flotronics, Inc]**
 - 4. **[Lockwood Products]**
 - 5. **[MEPCO, LLC.]**
 - 6. **[Shippensburg Pump Co., Inc]**
 - 7. **[Skidmore Pump]**
 - 8. **[U.S. Deaerator Co]**
 - 9. **<Insert manufacturer's name>**
- C. Description: Receiver mounted, consisting of multijet vacuum producer, centrifugal pump and motor assembly mounted on separation chamber, and automatic pressure and water temperature controls. Include the following accessories:

1. **[Liquid-filled industrial][Bimetal dial-type]** thermometer graduated in **[Fahrenheit][and][Celsius]**.
2. Vacuum Gage: Dial-type register in **inches of mercury (kPa)**.
3. Level Gage Glass: Stops top and bottom.
4. Air-suction check valve.
5. Lifting eyes.
6. Companion flanges.
7. Low-water cutoff switch.
8. Cooling-Water Control: Aquastat, inlet strainer, and electric valve.
9. Air vent.
10. Overflow drain from vacuum-producer receiver.
11. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A53/A53M, Type S (seamless), Grade B; or ASTM A106/A106M, Type S, Grade B, **[Schedule 40][Schedule 80]**; with threaded joints and fittings.
 - a. Cast-Iron Threaded Fittings: ASME B16.4; Class **[125][250]**.
 - b. Malleable-Iron Threaded Fittings: ASME B16.3, Class **[150][300]**.
 - c. Forged-Steel Fittings: ASME B16.11, Class 3000.
 - d. Malleable-Iron Unions: ASME B16.39; Class **[150][300]**.
 - e. Forged-Steel Unions: MSS SP-83, Class 3000.
12. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A53/A53M, Type E (electric-resistance welded), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule **[40][80]**; with welded joints and carbon-steel fittings and flanges.
 - a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
 - b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class **[150][300]**, including bolts, nuts, and gaskets.
13. Pump-discharge bypass with relief valve or orifice plate sized to provide continuous pump operation with boiler feedwater valve closed.
14. Threaded connection and provision for chemical injection quill.
15. Sample cooler.
16. **<Insert accessory>**.

D. Vacuum-Producer Reservoir and Vacuum Receiver:

1. Material: **[Close-grain cast iron][Welded carbon steel][Welded carbon steel galvanized after fabrication][Stainless steel]**.
2. Additional corrosion protection:
 - a. **[0.07-inch (1.8-mm)][0.13-inch (3.3-mm)][0.19-inch (4.8-mm)]<Insert dimension>** thickness allowance.
 - b. Electrolytic corrosion-inhibitor anode.
3. Finish: **[Primer][Primer under enamel topcoat][Primer under epoxy topcoat]**.
4. Factory-Applied Insulation and Jacket: Minimum thickness of **[2 inches (50 mm)]<Insert dimension>** for mineral-fiber pipe and tank insulation. Cover insulation with **[painted steel][stucco-embossed aluminum][stainless steel]** jacket.
5. Mounting Arrangement: **[Recessed below floor][Floor mounted]**.
6. Mounting Frame: Structural-steel stand to support receiver and pumps. **[Fabricate stand with bracing adequate for seismic forces, according to authorities having jurisdiction, and to allow anchoring mounting frame to floor.]**
7. Drain connection with valve.

E. Vertical Vacuum-Producer Pump: Flange-mounted, close-coupled, single-stage, radially split-case-

design centrifugal pump; rated for [175-psig (1205-kPa)]<Insert value> minimum working pressure and a continuous water temperature of at least [225 deg F (107 deg C)]<Insert temperature>; with the following features:

1. Impeller: Bronze.
2. Shaft: Stainless steel.
3. Seals: Mechanical.
4. Motor: [Open dripproof][Totally enclosed][Totally enclosed fan-cooled] enclosure. Comply with requirements in Section 230500 "Common Work Results for HVAC."

F. Horizontal Vacuum-Producer Pump: Base-mounted, single-stage, radially split-case-design centrifugal pump; rated for [175-psig (1205-kPa)]<Insert value> minimum working pressure and a continuous water temperature of at least [225 deg F (107 deg C)]<Insert temperature>; with the following features:

1. Impeller: Bronze.
2. Shaft: Stainless steel.
3. Coupling: [Close][Flexible].
4. Seals: Mechanical.
5. Motor: [Open dripproof][Totally enclosed][Totally enclosed fan-cooled] enclosure. Comply with requirements in Section 230500 "Common Work Results for HVAC."

G. Vertical Feedwater Pump: Flange-mounted, close-coupled, [single-stage,][multistage,] radially split-case-design centrifugal pump; rated for [175-psig (1205-kPa)]<Insert value> minimum working pressure and a continuous water temperature of at least [225 deg F (107 deg C)]<Insert temperature>; with the following features:

1. Impeller: [Bronze][Stainless steel].
2. Seals: Mechanical.
3. Motor: [Open dripproof][Totally enclosed][Totally enclosed fan-cooled] enclosure. Comply with requirements in Section 230500 "Common Work Results for HVAC."

H. Horizontal Feedwater Pump: Base-mounted, [single-stage,][multistage,] radially split-case-design centrifugal pump; rated for [175-psig (1205-kPa)]<Insert value> minimum working pressure and a continuous water temperature of at least [225 deg F (107 deg C)]<Insert temperature>; with the following features:

1. Impeller: [Bronze][Stainless steel].
2. Coupling: [Close][Flexible].
3. Seals: Mechanical.
4. Motor: [Open dripproof][Totally enclosed][Totally enclosed fan-cooled] enclosure. Comply with requirements in Section 230500 "Common Work Results for HVAC."

I. Control panel shall be unit mounted and factory wired and include the following:

1. Vacuum Switches for Simplex Vacuum-Producer Pumps: Include pressure adjustment, and test push button. Factory set to operate pump between 3 and 6 inches of mercury (10.1 and 20.2 kPa).
2. Vacuum Switches for Duplex Vacuum-Producer Pumps: Include pressure adjustment, and test push button. Factory set so one pump operates for 3 to 5 inches of mercury (10.1 to 16.9 kPa) and both pumps operate for 4 to 6 inches of mercury (13.5 to 20.2 kPa).
3. NEMA 250, [Type 1][Type 4][Type 4X][Type 12]<Insert type> enclosure.
4. Single-point field power interface to [fused disconnect switch][nonfused disconnect switch][circuit breaker]. Withstanding rating of disconnecting means shall protect equipment. Coordinate requirements with field electrical power source.

- a. Branch power circuit to each motor and to controls[**with a disconnect switch or circuit breaker**].
- 5. NEMA-rated motor controller for each motor and include a hand-off-auto switch and overcurrent protection.
 - a. Alternating control for multiple pump units with intermittent operation as indicated by control sequence.
 - b. Provide variable-frequency controller [**with manual bypass**]and line reactors for each variable-speed motor.
- 6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
- 7. Wiring outside of an enclosure in a [**metal**]raceway. Make connections to motor with liquidtight conduit.
- 8. Removable control mounting plate.
- 9. Visual indication of status and alarm[**with momentary test push button**].
- 10. Audible alarm and silence switch.
- 11. Visual indication of elapsed run time, graduated in hours.
- 12. Fused control-circuit transformer.
- J. Vacuum-Producer Control Sequence:
 - 1. Cycle pumps to maintain vacuum-pressure set point.
 - 2. Visual indication of pump on[**and off**] status.
 - 3. Visual[**and audible**] alarm indication of pump failure.
- K. Feedwater Single-Pump Control Sequence:
 - 1. Boiler water-level controller starts and stops pump to maintain boiler water-level set point.
 - 2. Visual indication of pump on[**and off**] status.
 - 3. Visual[**and audible**] alarm indication of pump failure.
- L. Feedwater Multi-Pump with Intermittent Operation Control Sequence:
 - 1. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
 - 2. Lead and lag pumps alternate [**after each start**][**to equalize run time**].
 - 3. Lead pump failure [**automatically starts lag pump if lead pump cannot maintain set point**][**manually starts lag pump**].
 - 4. Visual indication of pump on[**and off**] status.
 - 5. Visual indication of pump lead/lag status.
 - 6. Visual[**and audible**] alarm indication of pump failure.
- M. Feedwater Multi-Pump with Continuous Operation Control Sequence:
 - 1. Pump runs continuously while boiler operates. Electric interlock with boiler control starts lead pump when boiler starts.
 - 2. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
 - 3. Lead and lag pumps alternate [**after each start**][**to equalize run time**].
 - 4. Lead pump failure automatically starts lag pump.
 - 5. Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
 - 6. Feedwater pressure controller controls operating feedwater pump(s) speed and starts and stops lag pump(s) to maintain feedwater pressure set point.
 - 7. Visual indication of pump on[**and off**] status.
 - 8. Visual indication of pump lead/lag status.

9. Visual[**and audible**] alarm indication of pump failure.

N. Makeup Water Control Sequence:

1. Electric level controller operates electric control valve to maintain water temperature set point.
2. Visual[**and audible**] alarm indication of low[**and high**] water level.

O. Control System Interface: Factory install hardware to enable remote monitoring.

1. Hardwired Monitoring Points: On/off status for each pump[, **failure alarm for each pump**][, **receiver low-water-level alarm**][, **receiver high-water-level alarm**][, **feedwater temperature**]<Insert monitoring>.

P. Capacities and Characteristics:

1. Vacuum-Producer Reservoir:

- a. Volume: <Insert gal. (L)>.
- b. Diameter: <Insert inches (mm)>.
- c. Length: <Insert inches (mm)>.
- d. Cooling Makeup Water Supply: <Insert NPS (DN)>.
- e. Overflow Drain: <Insert NPS (DN)>.

2. Vacuum-Producer Pumps:

- a. No. of Pumps: [Simplex][Duplex]<Insert number>.
- b. Air Capacity: <Insert cfm (L/s)>.
- c. Head Pressure: <Insert inches of mercury (kPa)>.
- d. Horsepower: <Insert horsepower>.
- e. Speed: <Insert value> rpm.

3. Vacuum Receiver:

- a. Volume: <Insert gal. (L)>.
- b. Diameter: <Insert inches (mm)>.
- c. Length: <Insert inches (mm)>.
- d. Height to Condensate Inlet: <Insert inches (mm)>.
- e. Condensate Return Minimum Inlet Size: <Insert NPS (DN)>.

4. Feedwater Pumps:

- a. No. of Pumps: [Simplex][Duplex]<Insert number>.
- b. Flow Rate: <Insert gpm (L/s)>.
- c. NPSHR: <Insert psig (kPa)>.
- d. Rated Operating Temperature: <Insert deg F (deg C)>.
- e. Head Pressure: <Insert psig (kPa)>.
- f. Horsepower: <Insert horsepower>.
- g. Speed: <Insert value> rpm.

5. Unit Single-Point Power Electrical Characteristics:

- a. Volts: [208][460]<Insert value> V.
- b. Phase: Three.
- c. Hertz: 60.
- d. Full-Load Amperes: <Insert value>.

- e. Minimum Circuit Ampacity: **<Insert value>**.
- f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.4 SOURCE QUALITY CONTROL

- A. Factory Tests: Test performance and submit test results on packaged boiler feedwater pump units, according to ASME PTC 12.1, before shipping to Project.
- B. Witness Testing:
 - 1. Allow Owner access to witness source quality-control testing.
 - 2. Notify **[Architect][Owner][15]<Insert time>** days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting feedwater unit performance, maintenance, and operations.
 - 1. Boiler feedwater pump unit locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, control, and electrical connections.
- B. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping to verify actual locations of piping connections before installation of boiler feedwater pumps.
- C. Examine areas for suitable conditions where boiler feedwater pumps will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- B. Equipment Mounting:
 - 1. Install feedwater units on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install unit to permit access for maintenance.
- D. Support piping independent of equipment.
- E. Install parts and accessories shipped loose.
- F. Install control and electrical devices furnished with units that are not factory mounted.



- G. Install control and power wiring to field-mounted control and electrical devices furnished with units that are not factory installed.
- H. Protect units from corrosion.
 - 1. Before filling with water, protect by dry storage method recommended by manufacturer.
 - 2. After filled with water, protect by wet storage method recommended by manufacturer.
- I. Chemical Treatment: Quality of water in units shall be maintained by a professional water treatment organization that shall provide on-site supervision to maintain the required water quality during periods of storage, operating, standby, and test conditions. Comply with requirements in [Section 232500 "HVAC Water Treatment,"][Section 232519 "Water Treatment for Steam System Feedwater,"] for additional requirements.

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to boiler feedwater pumps, allow space for service and maintenance.
- C. Connect makeup water piping and cooling-water piping with reduced-pressure backflow preventers.
- D. Install overflow drain piping to nearest floor drain.
- E. Install piping from unit drain connections and extend to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation if required.
- F. Install vents and extend to outdoors; terminate with elbow turned down and an insect screen.
- G. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.
 - 1. Provide a temperature-controlled, non-potable, domestic cold water source to cool hot equipment drains to deliver a discharge temperature of <Insert temperature>.
- H. Connect chemical treatment piping to each boiler feedwater pump unit chemical treatment connection with check valve and isolation valve.

3.4 ELECTRICAL POWER CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

- B. Connect control wiring between boiler feedwater pump units and other equipment to interlock operation as required to provide a complete and functioning system.
- C. Connect control wiring between boiler feedwater pump unit control interface and control system to provide remote monitoring.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with manufacturer's written instructions.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Check bearing lubrication.
 - 4. Verify proper motor rotation.
 - 5. Startup service.
 - 6. Report results in writing.
- D. Boiler feedwater pump will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.7 ADJUSTING

- A. Adjust boiler water-level controls to properly stage unit.
- B. Set field-adjustable controls.

3.8 CLEANING

- A. Clean equipment internally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions. Following cleaning procedures, unit shall be washed and flushed until water leaving unit is clear.
- B. Clean strainers.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain boiler feedwater units.
- B. Video training sessions, and provide electronic copy of video to Owner.



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

END OF SECTION 23 53 13 00

SECTION 23 53 16 00 - DEAERATORS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Packaged, factory-assembled deaerators.

1.2 DEFINITIONS

- A. DDC: Direct digital control.
- B. Feedwater Pump: Pump that moves feedwater from the deaerator to the boiler.
- C. NPSHR: Net-positive suction head required.
- D. Transfer Pump: Pump that moves feedwater from the surge tank to the deaerator.

1.3 ACTION SUBMITTALS

- A. Product Data: For each unit to include the following:
 - 1. Equipment performance and operating characteristics, such as rated makeup water, feedwater, steam condensate and steam flow rates; working pressure; tank capacities, storage capacity in minutes; temperature and NPSHR; and pump performance curves with selection points clearly indicated.
 - 2. Furnished specialties and accessories.
 - 3. Construction details, material descriptions, dimensions and weight of individual components, and profiles and finishes.
 - 4. Force and moment capacity of each field piping connection.
 - 5. Dimensioned location of low, high, and normal water level showing operating set point and each alarm set point.
 - 6. Temperature and pressure rating, size, and materials of construction for trim components including, piping, fittings, flanges, unions, and valves. Provide valve manufacturer Product Data for each valve furnished. For safety valves, include trip and reset settings and flow capacity.
 - 7. Manufacturer Product Data showing size, scale range, and accuracy of thermometers and pressure gages.
 - 8. Detailed information of controls including Product Data with technical performance, operating characteristics, and sequence of operation.
 - 9. Product Data for each motor, including performance, operating characteristics, and materials of construction.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring. Differentiate between factory and field installation.



4. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

C. Delegated Design Submittals: For deaerators, signed and sealed by a qualified professional engineer.

1. Include design calculations for selecting [**vibration isolators and**] seismic restraints and for designing vibration isolation bases.
2. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan and elevation views, drawn to **<Insert scale>** scale, indicating equipment manufacturer's service clearances, structure and base attachment, piping, power, and controls. Each view to show screened background with the following:

1. Column grids, beams, columns, and concrete equipment bases.
2. Room layout with walls, floors, and roofs, including each room name and number.
3. Equipment and products located in vicinity of deaerators and part of final installation including products of other trades, such as lighting, fire suppression systems, and plumbing systems.

B. Seismic Qualification Certificates: For deaerators, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source quality-control reports.

D. Field quality-control reports.

E. Startup service reports.

F. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to deaerator.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For deaerators, components, and accessories to include in emergency, operation, and maintenance manuals.

B. Spare Parts List: Recommended spare parts list with quantity for each.

C. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.

D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Gaskets: Furnish **[one]<Insert number>** replacement gasket(s) for each gasketed opening.
 - 2. Gage Glass: Furnish **[one]<Insert number>** replacement glass(es) for each gage glass.
 - 3. Pump Mechanical Seal Set: Furnish **[one]<Insert number>** replacement mechanical seal set(s) for each unique pump mechanical seal.
 - 4. **<Insert extra materials>**.
- B. Tool Kit:
 - 1. A tool kit specially designed by deaerator manufacturer for use in servicing deaerator(s) furnished.
 - 2. Special tools required to service deaerator components not readily available to Owner service personnel in performing routine maintenance.
 - 3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Deaerator Tool Kit." Text size is to be at least **1 inch (25 mm)** high.
 - 4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size is to be at least **0.5 inch (13 mm)** high.
- C. Touchup Paint: **[32 oz. (1 L)]<Insert volume>** container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Ship deaerators from the factory free of water. Drain water and blow deaerators dry with compressed air if required to remove all water before shipping.
- B. Cover and protect flanges, pipe openings, nozzles, bearings, and couplings from damage during shipping, storage, and handling.
- C. Cover and protect electrical and control devices and open connections.
- D. Comply with manufacturer's written rigging instructions.
- E. Deliver deaerators as factory-assembled units with protective crating and covering.
 - 1. Package deaerator for export shipping in totally enclosed **[bagging][crate][crate with bagging]**.
- F. Protect deaerator components with removable temporary enclosures to prevent damage during shipping, storage, and installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Deaerator is to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the deaerator will remain in place without separation of any parts

when subjected to the seismic forces specified[**and the deaerator will be fully operational after the seismic event**]."

2. Component Importance Factor: [1.5][1.0].
3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

B. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system will automatically return equipment and associated controls to the operating state. This will occur immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source or through normal power if restored before backup power is brought on-line.
2. See Drawings for equipment served by backup power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

C. Outdoor Installations:

1. Deaerators are to be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a [25]**<Insert value>**-year period with minimal degradation due to exposure to outdoor ambient conditions.
2. Deaerators equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past [30]**<Insert value>**-year period.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. ASME Compliance: Fabricate and label deaerators and components to comply with ASME Boiler and Pressure Vessel Code.

2.2 PACKAGED, FACTORY-ASSEMBLED DEAERATORS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Ambassador Heat Transfer Company]**
2. **[Bethlehem Corporation (The)]**
3. **[Bryan Boilers; Bryan Steam LLC]**
4. **[Cleaver-Brooks]**
5. **[Cochrane, Inc.]**
6. **[Deaerating Designs]**
7. **[Eastern Industrial Products, Inc.]**
8. **[Ecodyne Limited]**
9. **[Enpro, Incorporated]**
10. **[Industrial Steam]**
11. **[International Boiler Works Co. (The)]**
12. **[Kansas City Deaerator Company]**
13. **[Lockwood Products]**
14. **[Nationwide Boiler Incorporated]**
15. **[Precision Boilers]**

16. [PVI; A WATTS Brand]
17. [Sellers Engineering Co]
18. [Skidmore Pump]
19. [Smith-Koch, Inc]
20. [Sterling Deaerator Co]
21. [U.S. Deaerator Co]
22. [York-Shipley Global; Division of Power Mechanical, Inc.]
23. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Ambassador Heat Transfer Company]
2. [Bethlehem Corporation (The)]
3. [Bryan Boilers; Bryan Steam LLC]
4. [Cleaver-Brooks]
5. [Cochrane, Inc.]
6. [Deaerating Designs]
7. [Eastern Industrial Products, Inc.]
8. [Ecodyne Limited]
9. [Enpro, Incorporated]
10. [Industrial Steam]
11. [International Boiler Works Co. (The)]
12. [Kansas City Deaerator Company]
13. [Lockwood Products]
14. [Nationwide Boiler Incorporated]
15. [Precision Boilers]
16. [PVI; A WATTS Brand]
17. [Sellers Engineering Co]
18. [Skidmore Pump]
19. [Smith-Koch, Inc]
20. [Sterling Deaerator Co]
21. [U.S. Deaerator Co]
22. [York-Shipley Global; Division of Power Mechanical, Inc.]
23. <Insert manufacturer's name>

C. [Horizontal][Vertical], [packed-column][spray][tray], single-compartment deaerator[, and a separate packaged surge tank with transfer and feedwater pumps and controls to supply feedwater to deaerator].

D. [Horizontal][Vertical], [packed-column][spray][tray], two-compartment deaerator. One compartment for deaeration and one for surge volume, each with its own transfer and feedwater pumps and controls.

E. [Horizontal][Vertical], [packed-column][spray][tray], single-compartment deaerator and separate surge tank, both mounted on same factory-fabricated stand with necessary transfer and feedwater pumps and controls.

F. Material for Wetted Components: Components in contact with water that has not been deaerated are to be made of Type [304][316] stainless steel.

G. Adjustable Spray Valves: Type 316 stainless steel. Arrange spray valves for counterflow of steam and condensate and so corrosive gases being vented do not contact deaerator's head or shell.

H. Vent Condenser: Stainless steel, with automatic and manual vent valves.

I. Deaerator and Storage Tank:



1. Material: **[Welded carbon steel][Welded carbon steel galvanized after fabrication][Stainless steel]**.
 2. Additional Corrosion Protection:
 - a. **[0.07-inch (1.8-mm)][0.13-inch (3.3-mm)][0.19-inch (4.8-mm)]<Insert dimension>** thickness allowance.
 - b. Electrolytic corrosion-inhibitor anode.
 3. Access: Manhole in deaerator and storage tank for access to internal components for inspection and service.
 - a. Manhole cover is to be **[dovetailed][or][hinged]**.
 4. Factory-Applied Insulation and Jacket:
 - a. Minimum thickness of **[2 inches (50 mm)]<Insert dimension>** for mineral-fiber pipe and tank insulation.
 - b. Cover insulation with preformed and removable sections of **[painted steel][stucco-embossed aluminum][or][stainless steel]** jacket to uniformly follow the contour of the tank. Jacket nominal thickness is not less than **[0.030 inch (0.8 mm)][0.048 inch (1.2 mm)]<Insert dimension>**.
 5. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A53/A53M, Type S (seamless), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule **[40][80]**; with threaded joints and fittings.
 - a. Cast-Iron Threaded Fittings: ASME B16.4, Class **[125][250]**.
 - b. Malleable-Iron Threaded Fittings: ASME B16.3, Class **[150][300]**.
 - c. Forged-Steel Fittings: ASME B16.11, Class 3000.
 - d. Malleable-Iron Unions: ASME B16.39, Class **[150][300]**.
 - e. Forged-Steel Unions: MSS SP-83, Class 3000.
 6. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A53/A53M, Type E (electric-resistance welded), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule **[40][80]**; with welded joints and carbon-steel fittings and flanges.
 - a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
 - b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class **[150][300]**, including bolts, nuts, and gaskets.
- J. Accessories:
1. Lifting eyes.
 2. Companion flanges.
 3. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
 4. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated in **[pounds force per square inch][kilopascals][both pounds force per square inch and kilopascals]**.
 5. Pump-discharge bypass **[relief valve][orifice plate][relief valve with orifice plate]** sized to provide continuous pump operation with boiler feedwater valve closed.
 6. Makeup Water Assembly:
 - a. Factory-mounted modulating valve with mechanical level control, external float cage, and stainless steel float.
 - b. **[Factory][Field]**-mounted, electric, **[pilot-operated, solenoid][modulating]** valve with

- factory-mounted, [**probe-type**]water-level controller.
 - c. [**Factory**][**Field**]-mounted, pneumatic modulating valve with factory-mounted water-level controller.
 - d. [**Factory**][**Field**]-mounted, three-valve bypass and inlet strainer.
- 7. Steam Pressure-Reducing Valve(s): [**Steam**][**Electric**][**Pneumatic**] operated[**with three-valve bypass**], and sized to reduce boiler outlet pressure to the deaerator design pressure.
- 8. Tank Overflow Drain: Sized to relieve full capacity at operating pressure.
- 9. Tank Overflow Drainer: Float-type trap, sized to relieve full capacity at operating pressure, with steel housing and stainless steel float ball.
- 10. Safety Valve(s): ASME labeled and sized to relieve full capacity of pressure-reducing valve. Provide each safety valve with a drip-pan elbow.[**For units installed outdoors, provide each safety valve vent with an exhaust head.**]
- 11. Vents: Manual and automatic vent valves.
 - a. Automatic air vents are to be thermostatically controlled to provide a fast means of venting when a sudden buildup of gas occurs.
 - b. Manual air vents are to have an orifice to provide continuous venting at a rate of up to 0.1 percent of rated deaerator capacity at operating pressure indicated.
 - c. For units installed outdoors, provide each vent with a drip-pan elbow and exhaust head.
- 12. High-temperature condensate diffuser tube.
- 13. Vacuum breaker.
- 14. Meters and Gages:
 - a. Full-height, water-level gage glass[, **reflex flat type**,] with gage rods to protect glass and stop valve set, ball check and shutoff cocks, water-column blowdown valves, and vacuum breaker.
 - b. Thermometer:
 - 1) [**Liquid-filled industrial**][**Bimetal dial-type**] thermometer graduated in [**Fahrenheit**][**Celsius**][**both Fahrenheit and Celsius**] mounted to measure temperature in storage [**and steam**]section of tank.
 - 2) Graduated scale with a range of approximately [**1.5**]**<Insert value>** times the normal operating temperature.
 - 3) Any angle position adjustment.
 - 4) Stainless steel case with nominal [**5-inch- (125-mm-)**]**<Insert dimension>** diameter face.
 - 5) Mount thermometer in a Type 316 stainless steel thermowell.
 - c. Pressure Gage:
 - 1) Pressure gage graduated in [**pounds force per square inch**][**kilopascals**][**both pounds force per square inch and kilopascals**] mounted to measure pressure in steam section of tank and pressure at feedwater discharge manifold pipe.
 - 2) Nominal [**4-inch- (100-mm-)**]**<Insert dimension>** diameter face with graduated scale and siphon with isolation valve. Gage is to have normal operating pressure about [**50**]**<Insert number>** percent of full range and an accuracy of [**0.5**][**1**] percent.
 - d. Flow meter mounted in feedwater discharge manifold pipe and positioned to measure and display flow supplied by deaerator to boilers. Accuracy within [**2**]**<Insert value>** of actual reading when measured across design to minimum flow range.
 - e. Meters and gages are to be easily readable by operator standing at grade adjacent to unit. Provide remote reading gages if required to comply with requirement.
- 15. Provision for chemical injection quill.



16. Chemical injection quill with check valve and isolation valve.
17. Sample Cooler: Factory **[installed][or][furnished for field installation]**, with **[needle]** valve for each connection. **[Constructed of Type 316 stainless steel.]**
18. Tank drain connection with valve.
19. Oxygen test kit.
20. **<Insert accessory>**.

K. Support Frame: Structural-steel frame for supporting tank and pumps. Weld or bolt to tank.

1. Fabricate support frame with bracing adequate for seismic forces in accordance with authorities having jurisdiction and to allow installation by anchoring deaerators to floor only.
2. Minimum height of frame is to be as required by application, but not less than **<Insert height>**.

L. Feedwater Pump: Cast-iron, **[flange][base]**-mounted volute; with **[bronze][stainless steel]**, **[multistage centrifugal][turbine]** impeller, renewable bronze case ring, and stainless steel shaft.

1. Seals: Mechanical, suitable for **[250 deg F (121 deg C)]<Insert temperature>**.
2. Pump Motor: **[Vertical][Horizontal]**, **[close][or][flexible]** coupled to pump. Comply with requirements in Section 230500 "Common Work Results for HVAC" unless more stringent requirements are indicated below:
 - a. Efficiency: **[Premium efficient]<Insert requirement>**.
 - b. Enclosure: **[Open dripproof][totally enclosed][or][totally enclosed fan cooled]**.
 - c. Insulation Class: **[F][H]<Insert requirement>**.
 - d. Service Factor: **[1.15]<Insert value>**.
 - e. Motors operated through variable-frequency controllers are to be inverter duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
3. Motor Sizes: Minimum size as indicated and large enough so driven load does not require motor to operate in service factor.

2.3 SURGE TANK ASSEMBLY

A. Description: Factory-assembled and -tested unit consisting of a condensate receiver, transfer pumps, and controls.

B. Accessories:

1. Thermometer:
 - a. **[Liquid-filled industrial][Bimetal dial-type]** thermometer graduated in **[Fahrenheit][Celsius][both Fahrenheit and Celsius]**.
 - b. Graduated scale with a range of approximately **[1.5]<Insert value>** times the normal operating temperature.
 - c. Any angle position adjustment.
 - d. Stainless steel case with nominal **[5-inch- (125-mm-)]<Insert dimension>** diameter face.
 - e. Mount thermometer in a Type 316 stainless steel thermowell.
2. Full-height, water-level gage glass[, **reflex flat type**,] with gage rods to protect glass and stop valve set, ball check and shutoff cocks, water-column blowdown valves, and vacuum breaker.
3. Lifting eyes.
4. Companion flanges.
5. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.

6. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated in **[pounds force per square inch][kilopascals][both pounds force per square inch and kilopascals]**. Gage with nominal **[4-inch- (100-mm-)]<Insert dimension>** diameter face, isolation valve, normal operating pressure about **[50]<Insert number>** percent of full range, and an accuracy of **[0.5][1]** percent.
 7. Gages are to be easily readable by operator standing at grade adjacent to unit. Provide remote reading gages if required to comply with requirement.
 8. Pump-discharge bypass **[relief valve][orifice plate][relief valve with orifice plate]** sized to provide continuous pump operation.
 9. **<Insert accessories>**.
- C. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A53/A53M, Type S (seamless), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule **[40][80]**; with threaded joints and fittings.
1. Cast-Iron Threaded Fittings: ASME B16.4, Class **[125][250]**.
 2. Malleable-Iron Threaded Fittings: ASME B16.3, Class **[150][300]**.
 3. Forged-Steel Fittings: ASME B16.11, Class 3000.
 4. Malleable-Iron Unions: ASME B16.39, Class **[150][300]**.
 5. Forged-Steel Unions: MSS SP-83, Class 3000.
- D. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A53/A53M, Type E (electric-resistance welded), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule **[40][80]**; with welded joints and carbon-steel fittings and flanges.
1. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
 2. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class **[150][300]**, including bolts, nuts, and gaskets.
- E. Tank:
1. Material: **[Welded carbon steel][Welded carbon steel galvanized after fabrication][Stainless steel]**.
 2. Additional Corrosion Protection:
 - a. **[0.07-inch (1.8-mm)][0.13-inch (3.3-mm)][0.19-inch (4.8-mm)]<Insert dimension>** thickness allowance.
 - b. Electrolytic corrosion-inhibitor anode.
 3. Access: Manhole in tank for access to internal components for inspection and service.
 - a. Manhole cover is to be **[davitd][or][hinged]**.
 4. Factory-Applied Insulation and Jacket:
 - a. Minimum thickness of **[2 inches (50 mm)]<Insert dimension>** for mineral-fiber pipe and tank insulation.
 - b. Cover insulation with preformed and removable sections of **[painted steel][stucco-embossed aluminum][stainless steel]** jacket to uniformly follow the contour of the tank. Jacket nominal thickness is not less than **[0.030 inch (0.8 mm)][0.048 inch (1.2 mm)]<Insert dimension>**.
- F. Support Frame: Structural-steel frame for supporting tank. Weld or bolt to tank.
1. Fabricate support frame with bracing adequate for seismic forces in accordance with authorities having jurisdiction and to allow installation by anchoring deaerators to floor only.
 2. Minimum height of frame is to be as required by application, but not less than **<Insert height>**.

G. Transfer Pump:

1. Vertical, flange-mounted, close-coupled, **[single-stage][multistage]**, radially split-case centrifugal pump; rated for **[175-psig (1205-kPa)]<Insert value>** minimum working pressure and a continuous water temperature of **[225 deg F (107 deg C)]<Insert temperature>**; with the following features:
 - a. Impeller: **[Bronze][Stainless steel]**.
 - b. Seals: Mechanical.
2. Horizontal, base-mounted, **[single-stage][multistage]**, radially split-case centrifugal pump; rated for **[175-psig (1205-kPa)]<Insert value>** minimum working pressure and a continuous water temperature of **[225 deg F (107 deg C)]<Insert temperature>**; with the following features:
 - a. Impeller: **[Bronze][Stainless steel]**.
 - b. Coupling: **[Close][Flexible]**.
 - c. Seals: Mechanical.

H. Transfer Pump Motor: Comply with requirements in Section 230500 "Common Work Results for HVAC" unless more stringent requirements are indicated below:

1. Efficiency: **[Premium efficient]<Insert requirement>**.
2. Enclosure: **[Open dripproof][totally enclosed][or][totally enclosed fan cooled]**.
3. Insulation Class: **[F][H]<Insert requirement>**.
4. Service Factor: **[1.15]<Insert value>**.
5. Motors operated through variable-frequency controllers is to be inverter duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
6. Motor Sizes: Minimum size as indicated and large enough so driven load does not require motor to operate in service factor.

2.4 CONTROLS

- A. Factory-installed and -wired controllers, meters, sensors, switches, transformers, transmitters, valves, and other control devices necessary to provide a complete and functioning unit to operate as indicated and connect to field control interfaces indicated.
- B. Operating controls include the following devices and features:
 1. Control transformer(s) with fuse protection, as required by manufacturer, to implement requirements indicated. Provide transformer with 25 percent spare capacity.
 2. Set-Point Adjust: Operating and alarm set points are to be field adjustable.
- C. Control Enclosures:
 1. NEMA 250, Type **[1][4][4X][12]<Insert type>**.
 - a. Provide enclosure with integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
 2. Wiring is to be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
 3. Mounted on deaerator assembly at a location convenient to operator.

4. Provide hinged full-size door with key lock. Provide common key for all locks.
 5. Enclosure is to consist of multiple sections divided by a partition with a separate hinged door for each section. One section houses low-voltage controls; other section houses line voltage controls.
 6. Enclosure houses the following:
 - a. Control transformers with fuses.
 - b. Labeled terminal strips.
 - c. **[Controller(s)][Microprocessor-based controller(s)]** to provide control and alarm functions indicated.
 - d. Audible indication of safety alarms.
 - e. Dry Contacts:
 - 1) For interface with chemical feed pump controls.
 - 2) **<Insert additional requirements>**.
 7. Face of enclosure provides the following:
 - a. Visual indication of operating components and alarms[**with momentary test push button**].
 - b. Visual indication of elapsed run time, graduated in hours.
 - c. Auto/local capability to allow operator to manual operate unit locally.
 - d. Audible alarm silence capability.
 - e. Labels for switches, lights, and displays to provide clear indication of service.
 8. For units with surge tank assembly mounted on a separate support frame from deaerator assembly, **[provide a separate][provide a common][manufacturer has option to provide a separate or common]** control panel for deaerator and surge tank assemblies.
- D. Control Instrument Enclosures: Control instruments and devices that are mounted on the deaerator assembly and cannot be installed inside the control enclosure is to have same or higher level of protection indicated for control enclosures.
- E. Control Cable and Wire:
1. Control cable and wiring is to be numbered and color-coded to match wiring diagram.
 2. Install cable and wiring located outside of enclosure(s) in a[**metal**] raceway.
 3. Use flexible conduit to make final terminations.
 4. Provide watertight installation for applications exposed to moisture.
- F. Touch-Screen Local Operator Interface: Provide local operator interface through a nominal **[10-inch (250-mm)]<Insert dimension>** touch-screen graphical color display for setup, monitoring, and data acquisition.
1. Monitoring:
 - a. Pump operating status (on/off).
 - b. Pump lead/lag status (lead/lag position).
 - c. Pump speed for variable-speed pumps (analog value, zero to 100 percent).
 - d. Pump operation failure alarm.
 - e. Pump starts.
 - f. Pump run time.
 - g. Feedwater pump manifold pipe discharge flow rate (analog valve).
 - h. Feedwater pump manifold pipe discharge pressure (analog valve, gage pressure).
 - i. Steam pressure (analog value, gage pressure).
 - j. Steam valve open position (analog value, zero to 100 percent).

- k. Tank water level (analog value).
- l. Tank high-water-level alarm (analog value).
- m. Tank low-water-level alarm (analog value).
- n. Tank low-water-level cutoff alarm (digital value).
- o. Makeup water valve open position (analog value, zero to 100 percent).
- p. Tank temperature (analog value).
- q. **<Insert monitoring>**.

2. Control Setup:

- a. Pump operation (on/off).
- b. Pump lead/lag operation (lead/lag position).
- c. Pump speed for variable-speed pumps (analog value, zero to 100 percent).
- d. Pump manifold pipe discharge pressure set point (analog value, gage pressure).
- e. Steam pressure set point (analog value, gage pressure).
- f. Steam valve open position override (analog value, zero to 100 percent).
- g. Tank water level set point (analog value).
- h. Tank high-water-level alarm set point (analog value).
- i. Tank low-water-level alarm set point (analog value).
- j. Tank low-water-level cutoff alarm set point (digital value).
- k. Makeup water valve open position override (analog value, zero to 100 percent).
- l. **<Insert control>**.

G. System Interface: Factory install hardware and software to enable **[building automation][DDC]** system to monitor, control, and display deaerator status and alarms.

1. Hardwired I/O Points:

- a. Monitoring: On/off status for each pump[, **failure alarm for each pump**][, **low-water-level alarm**][, **high-water-level alarm**][, **feedwater temperature**][, **feedwater flow rate**]**<Insert monitoring point>**.
- b. Control: On/off operation, **[on/off operation of each pump,][lead/lag position of each pump,][feedwater supply pressure set-point adjustment,][tank water level set-point adjustment]****<Insert control point>**.

2. Communication Interface: **[ASHRAE 135 (BACnet)][(LonTalk)][Modbus][Industry-accepted, open-protocol]****<Insert type of interface>** communication interface enables control system operator to remotely control and monitor deaerator operation from an operator workstation. Control features available, and monitoring points displayed, locally at deaerator control panel are to be available to control system through the interface.

H. Feedwater Pump Start-Stop Control Sequence:

- 1. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
- 2. Lead and lag pumps alternate **[after each start][to equalize run time]**.
- 3. Lead pump failure **[automatically starts lag pump if lead pump cannot maintain set point][manually starts lag pump]**.
- 4. Visual indication of pump on[**and off**] status.
- 5. Visual indication of pump starts.
- 6. Visual indication of pump run time.
- 7. Visual indication of pump lead/lag status.
- 8. Visual[**and audible**] alarm indication of pump failure.

I. Feedwater Pump Continuous Control Sequence:

1. Pump runs continuously while boiler operates. Electric interlock with boiler control to start lead pump when boiler starts.
2. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
3. Lead and lag pumps alternate **[after each start][to equalize run time]**.
4. Lead pump failure automatically starts lag pump.
5. Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
6. Feedwater pressure controller controls operating feedwater pump(s) speed and starts and stops lag pump(s) to maintain feedwater pressure set point.
7. Visual indication of pump on **[and off]** status.
8. Visual indication of pump starts.
9. Visual indication of pump run time.
10. Visual indication of pump lead/lag status.
11. Visual **[and audible]** alarm indication of pump failure.
12. Visual indication of feedwater flow rate.

J. Makeup Water Control Sequence:

1. Electric level controller operates electric control valve to maintain tank water-level set point.
2. Pneumatic level controller operates pneumatic control valve to maintain tank water-level set point.
3. Mechanical float operates valve to maintain water-level set point.
4. Visual **[and audible]** alarm indication of low **[and high]** tank water level.
5. Low-water level stops pumps.
6. Visual indication of makeup water flow rate.

K. Transfer Pump Start-Stop Control Sequence: Deaerator water-level controller controls lead pump; alternator switches lead and lag pump(s) **[after each start][to equalize run time]**; failure of lead pump switches to lag pump **[and sounds audible alarm]**.

L. Transfer Pump Continuous-Run Control Sequence: Lead pump runs continuously while deaerator is operating; deaerator water-level controller modulates water-level-control valve; lead and lag pump(s) switch to equalize run time; lag pump operates if lead pump fails **[; pump failure sounds audible alarm]**.

2.5 ELECTRICAL POWER

- A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary to provide a single-point field power connection to unit.
1. For units with surge tank assembly mounted on a separate support frame from deaerator assembly, **[provide a separate][provide a common][manufacturer has option to provide a separate or common]** field electrical connection for deaerator and surge tank assemblies.
 2. Enclosure: NEMA 250, Type **[1][4][4X][12]<Insert type>**.
 - a. Enclosure is to have integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
 - b. Mounted on deaerator assembly at a location convenient to operator.
 - c. Enclosure is to have hinged full-size door with key lock with common key for all locks.
 3. Wiring is to be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
 4. Install wiring outside of an enclosure in a **[metal]** raceway. Make final connections to motors using

- flexible conduit. Provide watertight installation for applications exposed to moisture.
5. Field power interface is to be to **[fused disconnect switch][nonfused disconnect switch][circuit breaker]**. Withstanding rating of disconnecting means is to protect equipment. Coordinate requirements with field electrical power source.
6. Provide branch power circuit to each motor and to controls **[with a disconnect switch or circuit breaker]**.
7. Provide each motor with NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection. Provide variable-frequency controller **[with manual bypass]** and line reactors for each variable-speed motor indicated.
 - a. Alternating control as indicated by control sequence for each pump.
8. Provide transformer with fuses and power wiring to power a 20-A, 120-V duplex receptacle mounted in each control panel for use in connecting analytical and testing equipment.

2.6 FACTORY FINISHES

- A. Manufacturer's standard prime-coat finish ready for field painting.
- B. Manufacturer's standard paint in standard colors, applied to factory-assembled and -tested unit before shipping.
- C. General:
 1. Paint deaerator, using manufacturer's standard procedures, except comply with requirements indicated.
 2. Miscellaneous surfaces are to be finished to match continuous surfaces.
 3. Manufacturer is to field touch-up or entirely repaint surface finishes, damaged during shipment, to original condition, using original materials and methods.
 4. Paint is to be suitable for temperatures encountered on painted surfaces.
 5. Requirements indicate minimum quality level. Provide more robust paint system if required to comply with other requirements indicated.
- D. Preparation:
 1. Follow paint manufacturer's published preparation and application instructions.
 2. When paint manufacturer's recommended preparation requirements differ from those specified, use more stringent requirements.
 3. Structural steel with visible corrosion is to be sandblasted in accordance with SSPC SP-6 or SSPC SP-10 before applying primer and paint.
 4. Before applying a primer and a topcoat, remove oil and grease from surfaces to be coated using clean rags soaked in thinner in accordance with SSPC SP-1.
 5. Treat galvanized-steel surfaces that cannot be procured with a phosphatized finish with a phosphate rinse to ensure proper paint adhesion.
- E. Primer:
 1. Rust-inhibiting type with a minimum dry film thickness of **[2 mils (0.05 mm)]<Insert thickness>**.
 2. Provide multiple passes if required to prevent runs.
 3. Select a primer that is compatible with substrate and with finish coat.
- F. Finish Coat:
 1. Finish coat is to be **[alkyd enamel][epoxy][polyurethane]<Insert type>**.

2. Use dry film thickness recommended by paint manufacturer, but not less than **[2 mils (0.05 mm)]<Insert thickness>**. Provide multiple passes if required to prevent runs.

G. Paint the following surfaces with primer and finish coat:

1. Base and miscellaneous supports that are not hot-dip galvanized.
2. Carbon steel that is not galvanized.
3. Exterior surfaces of unit exposed to view.
4. Piping and trim.

H. Do not paint aluminum, galvanized-steel, and stainless steel surfaces.

2.7 CAPACITIES AND CHARACTERISTICS

A. Nominal Capacity: **<Insert lb/h (kg/h)>**.

B. Design Feedwater Flow Rate: **<Insert gpm (L/s)>**.

C. Steam Flow Rate: **<Insert lb/h (kg/h)>**.

D. Steam Condensate Flow Rate: **<Insert gpm (L/s)>**.

E. Steam Condensate Temperature: **<Insert deg F (deg C)>**.

F. Makeup Water Flow Rate: **<Insert gpm (L/s)>**.

G. Makeup Water Temperature: **<Insert deg F (deg C)>**.

H. Capacity: Capable of raising temperature of condensate and makeup water to within **[3 deg F (2 deg C)]<Insert temperature>** of saturated steam temperature.

I. Minimum Working Pressure: **[50 psig (345 kPa)]<Insert value>**.

J. Operating Pressure Range: **[Atmospheric][From 2 to 15 psig (14 to 104 kPa)]<Insert pressure range>**.

K. Resultant Oxygen Content: Not more than **[0.03][0.005] cc/L** through an operating range between **[zero][3][5]<Insert number>** and 100 percent of full load.

L. Storage Tank:

1. Tank Capacity to Overflow: **<Insert gal. (L)>**.
2. Storage Time: **[10]<Insert number>** minutes.

M. Feedwater Pumps:

1. No. of Pumps: **[Duplex]<Insert quantity>**.
2. Design Flow Rate: **<Insert gpm (L/s)>**.
3. Minimum Flow Rate: **<Insert gpm (L/s)>**.
4. NPSHR: **<Insert psig (kPa)>**.
5. Rated Operating Temperature: **<Insert deg F (deg C)>**.
6. Head Pressure: **<Insert psig (kPa)>**.
7. Close-off Pressure: **<Insert psig (kPa)>**.
8. Horsepower: **<Insert value>**.

9. Speed: <Insert rpm>.

N. Surge Tank:

1. Tank Capacity to Overflow: <Insert gal. (L)>.
2. Storage Time: <Insert number> minutes.

O. Transfer Pumps:

1. No. of Pumps: [Duplex]<Insert quantity>.
2. Design Flow Rate: <Insert gpm (L/s)>.
3. Minimum Flow Rate: <Insert gpm (L/s)>.
4. NPSHR: <Insert psig (kPa)>.
5. Rated Operating Temperature: <Insert deg F (deg C)>.
6. Head Pressure: <Insert psig (kPa)>.
7. Close-off Pressure: <Insert psig (kPa)>.
8. Horsepower: <Insert value>.
9. Speed: <Insert rpm>.

P. Deaerator Assembly Single-Point Power Electrical Characteristics:

1. Volts: [208][230][460]<Insert value> V.
2. Phase: Three.
3. Hertz: 60.
4. Full-Load Amperes: <Insert value>.
5. Minimum Circuit Ampacity: <Insert value>.
6. Maximum Overcurrent Protection: <Insert amperage>.

Q. Surge Tank Assembly Single-Point Power Electrical Characteristics:

1. Volts: [208][230][460]<Insert value> V.
2. Phase: Three.
3. Hertz: 60.
4. Full-Load Amperes: <Insert value>.
5. Minimum Circuit Ampacity: <Insert value>.
6. Maximum Overcurrent Protection: <Insert amperage>.

2.8 SOURCE QUALITY CONTROL

- A. Fabricate and label deaerator tanks in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
- B. Factory install and test piping that connects pumps to tanks in accordance with [ASME B31.1, "Power Piping."][ASME B31.9, "Building Services Piping."].
- C. Factory Tests: Test performance and submit test results on packaged deaerator units, in accordance with ASME PTC 12.3, before shipping to Project.
- D. Witness Testing:
 1. Allow Owner access to witness source quality-control testing.
 2. Notify [Architect][Owner][15]<Insert time> days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting deaerator performance, maintenance, and operations.
 - 1. Deaerator locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping to verify actual locations of piping connections before installation of deaerators.
- C. Examine areas for suitable conditions where deaerators will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF PACKAGED, FACTORY-ASSEMBLED DEAERATORS

- A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- B. Equipment Mounting:
 - 1. Install deaerators on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install deaerators to permit access for service and maintenance.
- D. Where installing piping adjacent to machine, allow space for service and maintenance.
- E. Support piping independent of equipment.
- F. Install base-mounted pumps on concrete base with grouted base frame.
- G. Install all parts and materials not factory installed.
- H. Assemble and install deaerators trim, components, and accessories that are not factory installed.
- I. Install control and electrical devices furnished with deaerators that are not factory mounted.
- J. Install control and power wiring to field-mounted control and electrical devices furnished with deaerators that are not factory installed.
- K. Perform cleaning procedures in accordance with manufacturer's written instructions after completion of hydrostatic testing and before performing other field tests. Following cleaning procedures, deaerator is to be washed and flushed until water leaving deaerator is clear.
- L. Protect deaerators from corrosion.

1. Before filling with water, protect by dry storage method recommended by manufacturer.
2. After filled with water, protect by wet storage method recommended by manufacturer.

M. Chemical Treatment: Quality of water in deaerators is to be maintained by a professional water treatment organization that will provide on-site supervision to maintain the required water quality during periods of storage, operating, standby, and test conditions. See applicable water treatment Section, **<Insert Section number and title>**, for additional requirements.

3.3 PIPING CONNECTIONS

- A. Steam and condensate piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect steam and condensate piping to tank tapplings with shutoff valves and unions or flanges at each connection.
- C. Connect condensate drains, pump-discharge piping, vents, overflow drains, makeup water, steam supply, and cooling water piping.
 1. Extend overflow drains to **[floor][or][sanitary]** drains.
 2. Extend vent piping to outside and terminate with manufacturer-approved cap furnished with deaerator.
 3. Install piping from safety valves and drip-pan elbows. Extend piping from safety valves and terminate to vent outdoors. Extend piping from drip-pan elbow drain to nearest **[floor][or][sanitary]** drain.
 4. Install piping from equipment drain connection to nearest **[floor][or][sanitary]** drain. Piping is to be at least full size of connection. Provide an isolation valve if required.
- D. Hot equipment drains connected to sanitary drainage system is to be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.
 1. Provide a temperature-controlled, non-potable, domestic cold water source to cool hot equipment drains to deliver a discharge temperature of **<Insert temperature>**.
- E. Connect chemical treatment piping to each deaerator chemical treatment connection with check valve and isolation valve.
- F. Where installing piping adjacent to deaerators, allow space for service and maintenance.

3.4 ELECTRICAL POWER CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

- B. Connect control wiring between deaerators and other equipment to interlock operation as required to provide a complete and functioning system.
- C. Connect control wiring between deaerator control interface and **[DDC system]<Insert system description>** for remote monitoring and control of deaerators. Comply with requirements in **[Section 230923 "Direct Digital Control (DDC) System for HVAC."]<Insert Section number and title.>**

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections, for compliance with requirements.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Verify bearing lubrication.
 - 4. Verify proper motor rotation.
 - 5. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Deaerator will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Set makeup water-level controls.
 - 3. Set operating controls.
 - 4. Verify safety controls.
 - 5. Verify lubrication.
 - 6. Verify proper motor rotation.
 - 7. Start pumps in accordance with manufacturer's written instructions.
 - 8. **<Insert startup steps if any>**.
- B. Report: Prepare a written report to record the following:
 - 1. Procedures used.
 - 2. Initial findings.
 - 3. Final results.
 - 4. Corrective action taken to achieve compliance with requirements indicated.

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



5. Date of testing.
6. Name and contact information for person performing testing.

3.8 ADJUSTING AND CLEANING

- A. Adjust initial temperature and pressure set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges.
- C. Clean strainers.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain deaerators.
- B. Video training sessions, and provide electronic copy of video to Owner.

END OF SECTION 23 53 16 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 53 16 00	23 53 13 00	Boiler Feedwater Pumps



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 54 13 00 - ELECTRIC-RESISTANCE FURNACES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electric-resistance furnaces.
2. Thermostats and humidistats.
3. Air filters.
4. Air cleaners.
5. UV germicidal lights.
6. Humidifiers.
7. Ventilation air heat exchangers.
8. Refrigeration components.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals:

1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each furnace to include in emergency, operation, and maintenance manuals:

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

- a. Furnace and accessories complete with controls.
- b. Air filter.
- c. Air cleaner.
- d. UV germicidal light.
- e. Humidifier.
- f. Ventilation heat exchanger.
- g. Refrigeration components.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Disposable Air Filters: Furnish **[two]<Insert number>** complete sets.
 2. Disposable Air-Cleaner Media: Furnish **[one]<Insert number>** complete set(s).
 3. Fan Belts: Furnish **[one]<Insert number>** set(s) for each furnace fan.
 4. Disposable Humidifier Media: Furnish **[one]<Insert number>** set(s).

1.6 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- C. Comply with NFPA 70.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period:
 1. Warranty Period, Commencing on Date of Substantial Completion:
 - a. Furnace Heat Exchanger: **[10 years][20 years][Lifetime]<Insert value>**.
 - b. Integrated Ignition and Blower Control Circuit Board: **[Five years]<Insert value>**.
 - c. Draft-Inducer Motor: **[Five years]<Insert value>**.
 - d. Refrigeration Compressors: **[10 years][Lifetime]<Insert value>**.
 - e. Evaporator and Condenser Coils: **[Five years]<Insert value>**.
 - f. **<Insert components requiring extended warranty>**.

PART 2 - PRODUCTS

2.1 ELECTRIC-RESISTANCE FURNACES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. [Broan.; a Broan-NuTone LLC brand; a Nortek company]
 2. [Fedders North America Inc.]
 3. [Intertherm Heating and Cooling]
 4. [Wellman Furnaces, Inc.]
 5. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 6. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Broan.; a Broan-NuTone LLC brand; a Nortek company]
 2. [Fedders North America Inc.]
 3. [Intertherm Heating and Cooling]
 4. [Wellman Furnaces, Inc.]
 5. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 6. <Insert manufacturer's name>
- C. Furnace: Factory assembled, piped, wired, and tested.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency, and marked for intended location and application.
- E. Cabinet: Steel, with duct liner[**downstream from cooling coil**].
1. Duct Liner: Fiberglass, minimum [1/2 inch (13 mm)][3/4 inch (19 mm)] thick, complying with ASTM C1071 and having a coated surface exposed to airstream complying with NFPA 90A or NFPA 90B and with NAIMA's "Fibrous Glass Duct Liner Standard."
 - a. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 2. Factory paint external cabinets in manufacturer's standard color.
- F. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.
1. Fan Motors: Comply with requirements in Section 230500 "Common Work Results for HVAC."
 2. Special Motor Features:
 - a. Single speed, premium efficiency, as defined in Section 230500 "Common Work Results for HVAC," and with internal thermal protection and permanent lubrication.
 - b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - c. Electronically controlled motor (ECM) controlled by integrated furnace/blower control.
- G. Electric-Resistant Heating Elements: Helix-wound, nickel-chromium wire-heating elements in ceramic insulators mounted on steel supports.
- H. Heating-Element Control: Sequencer relay with relay for each element; switches elements on and off, with delay between each increment; initiates, stops, or changes fan speed.
- I. Summer Fan Switch: Connected to permit independent on-off switch of unit fan.
- J. Capacities and Characteristics:
1. Airflow Configuration: [Upflow][Counterflow][Horizontal].
 2. Electric Heating Element:

- a. Capacity: **<Insert MBh (kW)>**.
 - b. Number of Steps: **<Insert number>**.
 - c. Volts: **<Insert value>**.
 - d. Phase: **<Insert value>**.
 - e. Hertz: **<Insert value>**.
 - f. Full-Load Amperes: **<Insert value>**.
 - g. Minimum Circuit Ampacity: **<Insert value>**.
 - h. Maximum Overcurrent Protection: **<Insert amperage>**.
3. Fan:
 - a. Airflow: **<Insert cfm (L/s)>**.
 - b. External Static Pressure: **<Insert inches wg (Pa)>**.
 - c. Motor:
 - 1) Size: **<Insert horsepower>**.
 - 2) Speed: **<Insert rpm>**.
 - d. Volts: **<Insert value>**.
 - e. Phase: **<Insert value>**.
 - f. Hertz: **<Insert value>**.
 - g. Full-Load Amperes: **<Insert value>**.
 - h. Minimum Circuit Ampacity: **<Insert value>**.
 - i. Maximum Overcurrent Protection: **<Insert amperage>**.
4. Furnace Electrical Connection:
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.2 THERMOSTATS AND HUMIDISTATS

- A. Controls shall comply with requirements in ASHRAE/IES 90.1, "Controls."
- B. Solid-State Thermostat: **[Wall-mounted][Freestanding][Wireless]**, programmable, microprocessor-based unit with **[automatic][manual]** switching from heating to cooling, preferential rate control, seven-day programmability with minimum of four temperature presets per day, **[vacation mode]**, and battery backup protection against power failure for program settings.
- C. Single-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.
- D. Two-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.
- E. Heating-Only Thermostat: **[Single][Two]**-stage, wall-mounted unit with fan on-automatic selector.
- F. Solid-State, Combination Thermostat and Humidistat: **[Wall-mounted][Freestanding][Wireless]**, programmable, microprocessor-based unit with automatic switching from heating to cooling and humidifying to dehumidifying, preferential rate control, seven-day programmability with minimum of four



temperature presets per day, **[vacation mode]**, and battery backup protection against power failure for program settings.

G. Humidistat: Adjustable, **[wall][duct]**-mounted unit.

H. Control Wiring:

1. Balanced twisted-pair cabling **[complying with requirements for Category 5e in Section 260523 "Control Voltage Cables for Electrical Equipment."][complying with requirements for Category 5e in Section 271513 "Communications Copper Horizontal Cabling."]**
2. Balanced Twisted-Pair Cabling:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - 2) **[Belden Inc.]**
 - 3) **[Berk-Tek, a Leviton Company]**
 - 4) **[CommScope, Inc]**
 - 5) **[General Cable; Prysmian Group North America]**
 - 6) **[Hitachi Cable America Inc.]**
 - 7) **[Mohawk; a division of Belden Networking, Inc.]**
 - 8) **[West Penn Wire; brand of Belden, Inc.]**
 - 9) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - 2) **[Belden Inc.]**
 - 3) **[Berk-Tek, a Leviton Company]**
 - 4) **[CommScope, Inc]**
 - 5) **[General Cable; Prysmian Group North America]**
 - 6) **[Hitachi Cable America Inc.]**
 - 7) **[Mohawk; a division of Belden Networking, Inc.]**
 - 8) **[West Penn Wire; brand of Belden, Inc.]**
 - 9) **<Insert manufacturer's name>**
 - c. Description: **[Unshielded twisted pairs (UTP)][Shielded twisted pairs (FTP)][Screened twisted pairs (F/UTP)][Screened and shielded twisted pairs (F/FTP)]**, No. 24 AWG, 100 ohm, four pair.
 - d. Cable Jacket Color: **[Blue]<Insert color>**.

2.3 AIR FILTERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Aprilaire; Research Products Corp]**
 2. **[Filtrete Home Filtration Products; a 3M brand]**
 3. **[General Filters, Inc.]**



4. [Permatron Corporation]
5. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Aprilaire; Research Products Corp]
2. [Filtrete Home Filtration Products; a 3M brand]
3. [General Filters, Inc.]
4. [Permatron Corporation]
5. <Insert manufacturer's name>

C. Washable Filters: **1-inch- (25-mm-)** thick urethane pad.

D. Disposable Filters: [**1-inch- (25-mm-)**]**<Insert dimension>** thick fiberglass media[**with ASHRAE 52.2 MERV rating of 6 or higher,**] in sheet metal frame.

E. Charged Media Air Filters: Sheet metal housing arranged to be ducted in return-air duct connection to furnace; generates electrostatic charge; MERV 10 rating.

F. HEPA Air-Filter Units: Sheet metal housing with fan arranged to be ducted to return-air duct connection to furnace, with activated carbon prefilter[, **carbon VOC,**] and high-efficiency particulate air (HEPA) disposable filter. HEPA shall be as follows:

1. Standard: UL 586.
2. Rating: ASHRAE 52.2, 99.97 percent efficiency to 0.30-micrometer particle size.

2.4 AIR CLEANERS

A. Electronic Air Cleaners: Packaged system, including sheet metal housing, prefilter, power supply, and automatic control device, arranged for mounting in return-air duct at furnace; equip with on-off and test switches and pilot light.

1. Standard: UL 586.
2. Rating: ASHRAE 52.2, particle size to 0.01 micrometer.
3. Static Pressure Drop: Maximum **0.14-inch wg (35 Pa)** at **300-fpm (1.52-m/s)** air velocity.

B. Capacities and Characteristics:

1. Volts: <Insert value>.
2. Phase: <Insert value>.
3. Hertz: <Insert value>.
4. Minimum Circuit Ampacity: <Insert value>.
5. Maximum Overcurrent Protection: <Insert amperage>.

2.5 UV GERMICIDAL LIGHTS

A. Description: Lighting unit in metal housing arranged for installation in supply-air duct and controlled to cycle on and off with furnace fan, with [**one**][**two**] 75-W UV-light bulb(s).

2.6 HUMIDIFIERS

- A. Minimum capacity rating indicated according to AHRI 610.
- B. Media-wheel bypass type with bypass damper and motor-driven media wheel in reservoir with float-valve level control; arranged for mounting on return duct or plenum with bypass connection to supply duct.
- C. Wetted-pad, continuous-drain, bypass type with bypass damper and water-flow control orifice; arranged for mounting on return duct or plenum with bypass connection to supply duct.
- D. Fan-powered, wetted-pad, continuous-drain type with water-flow control orifice and motor; arranged for mounting on duct or plenum.
- E. Pumped, fan-powered, wetted-pad type with reservoir-level control and pump and fan motors; arranged for mounting on duct or plenum.
- F. Steam type with electric heating element in stainless-steel reservoir with float-valve level control; arranged for attachment to duct or plenum and for control by humidistat.
- G. Comply with applicable requirements in ASHRAE 62.1.
- H. Capacities and Characteristics:
 - 1. Type: **[Steam][Media wheel][Wetted pad with reservoir][Wetted pad with continuous drain][Wetted-pad bypass]**.
 - 2. Steam Capacity: **<Insert lb/h (kg/h)>**.
 - 3. Water Connection Size: **<Insert NPS (DN)>**.
 - 4. Drain Connection Size: **<Insert NPS (DN)>**.
 - 5. Volts: **<Insert value>**.
 - 6. Phase: **<Insert value>**.
 - 7. Hertz: **<Insert value>**.
 - 8. Minimum Circuit Ampacity: **<Insert value>**.
 - 9. Maximum Overcurrent Protection: **<Insert amperage>**.

2.7 VENTILATION AIR HEAT EXCHANGERS

- A. Cabinet: Steel, with factory-installed interior insulation and manufacturer's standard factory finish. Fabricate with space for piping and electrical conduits.
- B. Heat-Recovery Device: Fixed-plate, polypropylene copolymer (high-density plastic) heat-exchanger plates evenly spaced and sealed and arranged for counter airflow.
- C. Supply and Exhaust Fans: Forward curved centrifugal with direct drive. Motors comply with requirements in Section 230500 "Common Work Results for HVAC."
- D. Filters: **1-inch- (25-mm-)** thick disposable type **[with ASHRAE 52.2 MERV rating of 6 or higher]**, in galvanized-steel frame, mounted upstream of unit in both supply and exhaust airstreams.
- E. Wiring: Wire motors and controls so only external connections are required during installation.

2.8 REFRIGERATION COMPONENTS

- A. General Refrigeration Component Requirements:
1. Refrigeration compressor, coils, and specialties shall be designed to operate with CFC-free refrigerants.
 2. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1.
- B. Refrigerant Coil: Copper tubes mechanically expanded into aluminum fins. Comply with AHRI 210/240. Match size with furnace. Include condensate drain pan with accessible drain outlet[**complying with ASHRAE 62.1**].
1. Refrigerant Coil Enclosure: Steel, matching furnace and evaporator coil, with access panel and flanges for integral mounting at or on furnace cabinet and galvanized sheet metal drain pan coated with black asphaltic base paint.
- C. Refrigerant Line Kits: Annealed-copper suction and liquid lines factory cleaned, dried, pressurized with nitrogen, sealed, and with suction line insulated. Provide in standard lengths for installation without joints, except at equipment connections.
1. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type I, [1/2 inch (13 mm)][1 inch (25 mm)]<Insert dimension> thick.
- D. Refrigerant Piping: Comply with requirements in Section 232300 "Refrigerant Piping."
- E. Air-Cooled Compressor-Condenser Unit:
1. Casing: Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
 2. Compressor: Hermetically sealed [**reciprocating**][or][**scroll**] type.
 - a. Crankcase heater.
 - b. [**Restrained vibration**][**Vibration**] isolation mounts for compressor.
 - c. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - d. Two-speed compressor motors shall have manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - e. Refrigerant Charge: [**R-407C**][**R-410A**]<Insert type>.
 - f. Refrigerant: R-407C or R-410A.
 3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with liquid subcooler.
 4. Heat-Pump Components: Reversing valve and low-temperature air cutoff thermostat.
 5. Fan: Aluminum-propeller type, directly connected to motor.
 6. Motor: Permanently lubricated, with integral thermal-overload protection.
 7. Low Ambient Kit: Permits operation down to **45 deg F (7 deg C)**.
 8. Mounting Base: Polyethylene.
- F. Capacities and Characteristics:
1. Refrigerant Coil:
 - a. Total Cooling Capacity: <Insert Btu/h (kW)>.
 - b. Sensible Cooling Capacity: <Insert Btu/h (kW)>.

- c. Heating Capacity: **<Insert Btu/h (kW)>**.
- d. Maximum Air Pressure Drop: **<Insert inches wg (Pa)>**.
- e. Condensate Drain Size: **<Insert NPS (DN)>**.
- 2. Compressor-Condenser Unit:
 - a. Cooling Energy Efficiency[**(EER)**][**(SEER)**]: **<Insert value>**.
 - b. Heating Coefficient of Performance: **<Insert value>**.
 - c. Volts: **<Insert value>**.
 - d. Phase: **<Insert value>**.
 - e. Hertz: **<Insert value>**.
 - f. Full-Load Amperes: **<Insert value>**.
 - g. Minimum Circuit Ampacity: **<Insert value>**.
 - h. Maximum Overcurrent Protection: **<Insert amperage>**.
 - i. Fan Motor Full-Load Amperes: **<Insert value>**.
 - j. Compressor Running-Load Amperes: **<Insert value>**.
 - k. Compressor Motor Full-Load Amperes: **<Insert value>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine factory-installed insulation before furnace installation. Reject units that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Suspended Units: Suspend from structure using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
 - 1. Install seismic restraints to limit movement of furnace by resisting code-required seismic acceleration.
- B. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.
 - 1. Anchor furnace to substrate to resist code-required seismic acceleration.
- C. Controls: Install thermostats and humidistats at mounting height of **60 inches (1500 mm)** above floor.
- D. Wiring Method: Install control wiring in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal control wiring except in unfinished spaces.
- E. Install ground-mounted, compressor-condenser components on **4-inch- (100-mm-)** thick, reinforced

concrete base; **4 inches (100 mm)** larger on each side than unit. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

- F. Install ground-mounted compressor-condenser components on polyethylene mounting base.
- G. Install roof-mounted compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

3.3 CONNECTIONS

- A. Install piping adjacent to equipment to allow service and maintenance.
- B. Water piping installation requirements are specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties. Connect water piping with union and ball valve.
- C. Connect ducts to furnace with flexible connector. Comply with requirements in Section 233300 "Air Duct Accessories."
- D. Connect refrigerant tubing kits to refrigerant coil in furnace and to air-cooled compressor-condenser unit.
 - 1. Flared Joints: Use ASME B16.26 fitting and flared ends, following procedures in CDA's "Copper Tube Handbook."
 - 2. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
 - 3. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Comply with requirements in Section 232300 "Refrigerant Piping" for installation and joint construction of refrigerant piping.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Perform electrical test and visual and mechanical inspection.
 - 2. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
 - 4. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
 - 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

3.5 STARTUP SERVICE

- A. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - 1. Inspect for physical damage to unit casings.
 - 2. Verify that access doors move freely and are weathertight.
 - 3. Clean units and inspect for construction debris.
 - 4. Verify that all bolts and screws are tight.
 - 5. Adjust vibration isolation and flexible connections.
 - 6. Verify that controls are connected and operational.
- B. Adjust fan belts to proper alignment and tension.
- C. Start unit according to manufacturer's written instructions and complete manufacturer's operational checklist.
- D. Measure and record airflows.
- E. Verify proper operation of capacity control device.
- F. After startup and performance test, lubricate bearings[**and adjust belt tension**].

3.6 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set controls, burner, and other adjustments for optimum heating performance and efficiency. Adjust heat-distribution features, including shutters, dampers, and relays, to provide optimum heating performance and system efficiency.

3.7 CLEANING

- A. After completing installation, clean furnaces internally according to manufacturer's written instructions.
- B. Install new filters in each furnace within 14 days after Substantial Completion.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 23 54 13 00



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 54 16 13 - GAS-FIRED FURNACES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Gas-fired furnaces, noncondensing.
2. Gas-fired furnaces, condensing.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals:

1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Product Data: For adhesives, indicating VOC content.
4. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each furnace to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Furnace and accessories complete with controls.
 - b. Air filter.
 - c. Air cleaner.

- d. UV germicidal light.
- e. Humidifier.
- f. Ventilation heat exchanger.
- g. Refrigeration components.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Disposable Air Filters: Furnish **[two]<Insert number>** complete sets.
 - 2. Disposable Air-Cleaner Media: Furnish **[one]<Insert number>** complete set(s).
 - 3. Fan Belts: Furnish **[one]<Insert number>** set(s) for each furnace fan.
 - 4. Disposable Humidifier Media: Furnish **[one]<Insert number>** set(s).

1.6 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- C. Comply with NFPA 70.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period:
 - 1. Warranty Period, Commencing on Date of Substantial Completion:
 - a. Furnace Heat Exchanger: **[10 years][20 years][Lifetime]<Insert value>**.
 - b. Integrated Ignition and Blower Control Circuit Board: **[Five years]<Insert value>**.
 - c. Draft-Inducer Motor: **[Five years]<Insert value>**.
 - d. Refrigeration Compressors: **[10 years][Lifetime]<Insert value>**.
 - e. Evaporator and Condenser Coils: **[Five years]<Insert value>**.
 - f. **<Insert components requiring extended warranty>**.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency, and marked for intended location and application.
- B. General Requirements for Noncondensing Gas-Fired Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.

2.2 GAS-FIRED FURNACES, NONCONDENSING

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Adams Manufacturing Company]**
 2. **[Amana Heating & Air Conditioning; under license to Goodman Company, L.P.]**
 3. **[Arcoaire; Carrier Global Corporation]**
 4. **[Bard Manufacturing Company]**
 5. **[Bryant; Carrier Global Corporation]**
 6. **[Carrier Global Corporation]**
 7. **[Comfort-Aire; a division of Heat Controller, Inc.]**
 8. **[Comfortmaker; Carrier Global Corporation]**
 9. **[Dornback Furnace]**
 10. **[Goodman Manufacturing Company, L.P.]**
 11. **[Heil; Carrier Global Corporation]**
 12. **[Lennox]**
 13. **[Luxaire; brand of Johnson Controls International plc, Building Solutions North America]**
 14. **[Ruud Air Conditioning Division]**
 15. **[Tempstar; Carrier Global Corporation]**
 16. **[Thermo Products, Inc.]**
 17. **[Trane]**
 18. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 19. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Adams Manufacturing Company]**
 2. **[Amana Heating & Air Conditioning; under license to Goodman Company, L.P.]**
 3. **[Arcoaire; Carrier Global Corporation]**
 4. **[Bard Manufacturing Company]**
 5. **[Bryant; Carrier Global Corporation]**
 6. **[Carrier Global Corporation]**
 7. **[Comfort-Aire; a division of Heat Controller, Inc.]**
 8. **[Comfortmaker; Carrier Global Corporation]**
 9. **[Dornback Furnace]**
 10. **[Goodman Manufacturing Company, L.P.]**
 11. **[Heil; Carrier Global Corporation]**
 12. **[Lennox]**
 13. **[Luxaire; brand of Johnson Controls International plc, Building Solutions North America]**
 14. **[Ruud Air Conditioning Division]**
 15. **[Tempstar; Carrier Global Corporation]**
 16. **[Thermo Products, Inc.]**
 17. **[Trane]**
 18. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 19. **<Insert manufacturer's name>**
- C. Cabinet: **[Steel][Galvanized steel]**.
1. Cabinet interior around heat exchanger shall be factory-installed insulation.
 2. Lift-out panels shall expose burners and all other items requiring access for maintenance.
 3. Factory paint external cabinets in manufacturer's standard color.
 4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

- D. Fan: Centrifugal, factory balanced, resilient mounted, **[direct drive][belt drive][direct or belt drive][drive type indicated on Drawings]**.
1. Fan Motors: Comply with requirements in Section 230500 "Common Work Results for HVAC."
 2. Special Motor Features, Single Speed: Single speed, premium efficiency, as defined in Section 230500 "Common Work Results for HVAC," and with internal thermal protection and permanent lubrication.
 3. Special Motor Features, Multispeed: Multitapped, multispeed with internal thermal protection and permanent lubrication.
 4. Special Motor Features, ECM: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.
- E. Type of Gas: **[Natural][Propane]**.
- F. Heat Exchanger: **[Aluminized][Stainless]** steel.
- G. Burner:
1. Gas Valve: 100 percent safety **[two-stage][modulating]** main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
 2. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.
- H. Gas-Burner Safety Controls:
1. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
 2. Flame Rollout Switch: Installed on burner box; prevents burner operation.
 3. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
- I. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.
- J. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; and adjustable fan-on and fan-off timing; terminals for connection to accessories.
- K. Vent Materials: Comply with requirements in Section 235123 "Gas Vents" for Type B metal vents.
- L. Capacities and Characteristics:
1. Airflow Configuration: **[Upflow][Counterflow][Horizontal]**.
 2. Gas:
 - a. Type: **[Natural][Propane]**.
 - b. Venting Type: **[Power venter][with combustion-air intake]**.
 - c. Minimum Efficiency AFUE: **<Insert number>** percent.
 - d. Minimum Thermal Efficiency: **<Insert number>** percent.
 - e. Minimum Combustion Efficiency: **<Insert number>** percent.
 - f. Input: **<Insert MBh (kW)>**.
 - g. Heat Output: **<Insert MBh (kW)>**.
 - h. Gas Connection Size: **<Insert NPS (DN)>**.
 - i. Draft-Inducer Motor:

- 1) Size: <Insert horsepower>.
- 2) Speed: <Insert rpm>.

- j. Combustion-Air Inlet Size: <Insert inches (mm)>.
- k. Combustion-Air Inlet Material: [Galvanized steel][Stainless steel][PVC].
- l. Heat-Exchanger Condensate Drain Size: <Insert NPS (DN)>.
- m. Vent Size: <Insert inches (mm)>.

3. Fan:
 - a. Airflow: <Insert cfm (L/s)>.
 - b. External Static Pressure: <Insert inches wg (Pa)>.
 - c. Motor:
 - 1) Size: <Insert horsepower>.
 - 2) Speed: <Insert rpm>.
 - d. Volts: <Insert value>.
 - e. Phase: <Insert value>.
 - f. Hertz: <Insert value>.
 - g. Full-Load Amperes: <Insert value>.
 - h. Minimum Circuit Ampacity: <Insert value>.
 - i. Maximum Overcurrent Protection: <Insert amperage>.

4. Furnace Electrical Connection:
 - a. Volts: <Insert value>.
 - b. Phase: <Insert value>.
 - c. Hertz: <Insert value>.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

2.3 GAS-FIRED FURNACES, CONDENSING

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Adams Manufacturing Company]
2. [Amana Heating & Air Conditioning; under license to Goodman Company, L.P.]
3. [Arcoaire; Carrier Global Corporation]
4. [Bryant; Carrier Global Corporation]
5. [Carrier Global Corporation]
6. [Comfort-Aire; a division of Heat Controller, Inc.]
7. [Comfortmaker; Carrier Global Corporation]
8. [Dornback Furnace]
9. [Goodman Manufacturing Company, L.P.]
10. [Heil; Carrier Global Corporation]
11. [Lennox]
12. [Luxaire; brand of Johnson Controls International plc, Building Solutions North America]
13. [Ruud Air Conditioning Division]
14. [Tempstar; Carrier Global Corporation]
15. [Thermo Products, Inc.]
16. [Trane]



17. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
18. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Adams Manufacturing Company]
2. [Amana Heating & Air Conditioning; under license to Goodman Company, L.P.]
3. [Arcoaire; Carrier Global Corporation]
4. [Bryant; Carrier Global Corporation]
5. [Carrier Global Corporation]
6. [Comfort-Aire; a division of Heat Controller, Inc.]
7. [Comfortmaker; Carrier Global Corporation]
8. [Dornback Furnace]
9. [Goodman Manufacturing Company, L.P.]
10. [Heil; Carrier Global Corporation]
11. [Lennox]
12. [Luxaire; brand of Johnson Controls International plc, Building Solutions North America]
13. [Ruud Air Conditioning Division]
14. [Tempstar; Carrier Global Corporation]
15. [Thermo Products, Inc.]
16. [Trane]
17. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
18. <Insert manufacturer's name>

C. Cabinet: [Steel][Galvanized steel].

1. Cabinet interior around heat exchanger shall be factory-installed insulation.
2. Lift-out panels shall expose burners and all other items requiring access for maintenance.
3. Factory paint external cabinets in manufacturer's standard color.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.

1. Fan Motors: Comply with requirements in Section 230500 "Common Work Results for HVAC."
2. Special Motor Features, Single Speed: Single speed, premium efficiency, as defined in Section 230500 "Common Work Results for HVAC," and with internal thermal protection and permanent lubrication.
3. Special Motor Features, Multispeed: Multitapped, multispeed with internal thermal protection and permanent lubrication.
4. Special Motor Features, ECM: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.

E. Type of Gas: [Natural][Propane].

F. Heat Exchanger:

1. Primary: [Aluminized][Stainless] steel.
2. Secondary: [Polyethylene-coated][Stainless] steel.

G. Burner:

1. Gas Valve: 100 percent safety [two-stage][modulating] main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and

- combination ignition/fan timer control board.
 - 2. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.
- H. Gas-Burner Safety Controls:
- 1. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
 - 2. Flame Rollout Switch: Installed on burner box; prevents burner operation.
 - 3. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
- I. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.
- J. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; terminals for connection to accessories[; **diagnostic light with viewport**].
- K. Accessories:
- 1. Combination Combustion-Air Intake and Vent: PVC plastic fitting to combine combustion-air inlet and vent through [**outside wall**][**roof**].
 - 2. CPVC Plastic Vent Materials:
 - a. CPVC Plastic Pipe: Schedule 40, complying with ASTM F441/F441M.
 - b. CPVC Plastic Fittings: Schedule 40, complying with ASTM F438, socket type.
 - c. CPVC Solvent Cement: ASTM F493.
 - 1) Solvent cement shall have a VOC content of 490 g/L or less.
 - 2) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 3) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 4) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - 5) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 6) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
 - 3. PVC Plastic Vent Materials:
 - a. PVC Plastic Pipe: Schedule 40, complying with ASTM D1785.

- b. PVC Plastic Fittings: Schedule 40, complying with ASTM D2466, socket type.
 - c. PVC Solvent Cement: ASTM D2564.
 - 1) Adhesive primer shall have a VOC content of 550 g/L or less.
 - 2) Solvent cement shall have a VOC content of 510 g/L or less.
 - 3) Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 4) Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 5) Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - 6) Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit or 33 mcg/cu. m and that of acetaldehyde shall not exceed 9 mcg/cu. m.
 - 7) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 8) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 9) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - 10) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 11) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- L. Capacities and Characteristics:
- 1. Airflow Configuration: [**Upflow**][**Counterflow**][**Horizontal**].
 - 2. Gas:
 - a. Type: [**Natural**][**Propane**].
 - b. Venting Type: [**Power venter**][**Power venter with combustion-air intake**].

- c. Minimum Efficiency AFUE: **<Insert number>** percent.
 - d. Minimum Thermal Efficiency: **<Insert number>** percent.
 - e. Minimum Combustion Efficiency: **<Insert number>** percent.
 - f. Input: **<Insert MBh (kW)>**.
 - g. Heat Output: **<Insert MBh (kW)>**.
 - h. Gas Connection Size: **<Insert NPS (DN)>**.
 - i. Draft-Inducer Motor:
 - 1) Size: **<Insert horsepower>**.
 - 2) Speed: **<Insert rpm>**.
 - j. Combustion-Air Inlet Size: **<Insert inches (mm)>**.
 - k. Combustion-Air Inlet Material: **[CPVC][PVC]**.
 - l. Heat-Exchanger Condensate Drain Size: **<Insert NPS (DN)>**.
 - m. Vent Size: **<Insert inches (mm)>**.
 - n. Vent Material: **[CPVC][PVC]**.
3. Fan:
- a. Airflow: **<Insert cfm (L/s)>**.
 - b. External Static Pressure: **<Insert inches wg (Pa)>**.
 - c. Motor:
 - 1) Size: **<Insert horsepower>**.
 - 2) Speed: **<Insert rpm>**.
 - d. Volts: **<Insert value>**.
 - e. Phase: **<Insert value>**.
 - f. Hertz: **<Insert value>**.
 - g. Full-Load Amperes: **<Insert value>**.
 - h. Minimum Circuit Ampacity: **<Insert value>**.
 - i. Maximum Overcurrent Protection: **<Insert amperage>**.
4. Furnace Electrical Connection:
- a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.4 THERMOSTATS AND HUMIDISTATS

- A. Controls shall comply with requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."
- B. Solid-State Thermostat: **[Wall-mounted][Freestanding][Wireless]**, programmable, microprocessor-based unit with **[automatic][manual]** switching from heating to cooling, preferential rate control, seven-day programmability with minimum of four temperature presets per day, **[vacation mode]**, and battery backup protection against power failure for program settings.
- C. Single-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.

- D. Two-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.
- E. Heating-Only Thermostat: **[Single][Two]**-stage, wall-mounted unit with fan on-automatic selector.
- F. Solid-State, Combination Thermostat and Humidistat: **[Wall-mounted][Freestanding][Wireless]**, programmable, microprocessor-based unit with automatic switching from heating to cooling and humidifying to dehumidifying, preferential rate control, seven-day programmability with minimum of four temperature presets per day, **[vacation mode]**, and battery backup protection against power failure for program settings.
- G. Humidistat: Adjustable, **[wall][duct]**-mounted unit.
- H. Control Wiring: Balanced twisted-pair cabling complying with requirements for Category 5e in **[Section 260523 "Control-Voltage Electrical Power Cables."][Section 271513 "Communications Copper Horizontal Cabling."]**
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - b. **[Belden Inc.]**
 - c. **[Berk-Tek, a Leviton Company]**
 - d. **[CommScope, Inc]**
 - e. **[General Cable; Prysmian Group North America]**
 - f. **[Hitachi Cable America Inc.]**
 - g. **[Mohawk; a division of Belden Networking, Inc.]**
 - h. **[West Penn Wire; brand of Belden, Inc.]**
 - i. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - b. **[Belden Inc.]**
 - c. **[Berk-Tek, a Leviton Company]**
 - d. **[CommScope, Inc]**
 - e. **[General Cable; Prysmian Group North America]**
 - f. **[Hitachi Cable America Inc.]**
 - g. **[Mohawk; a division of Belden Networking, Inc.]**
 - h. **[West Penn Wire; brand of Belden, Inc.]**
 - i. **<Insert manufacturer's name>**
 3. Description: **[Unshielded twisted pairs (UTP)][Shielded twisted pairs (FTP)][Screened twisted pairs (F/UTP)][Screened and shielded twisted pairs (F/FTP)]**, No. 24 AWG, 100 ohms, four pair.
 4. Cable Jacket Color: **[Blue]<Insert color>**.

2.5 AIR FILTERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide**

products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Aprilaire; Research Products Corp]
2. [Filtrete Home Filtration Products; a 3M brand]
3. [General Filters, Inc.]
4. [Permatron Corporation]
5. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Aprilaire; Research Products Corp]
2. [Filtrete Home Filtration Products; a 3M brand]
3. [General Filters, Inc.]
4. [Permatron Corporation]
5. <Insert manufacturer's name>

- C. Washable Filters: 1-inch- (25-mm-) thick urethane pad.

- D. Disposable Filters: [1-inch- (25-mm-)]<Insert dimension> thick fiberglass media[with ASHRAE 52.2 MERV rating of 6 or higher,] in sheet metal frame.

- E. Charged Media Air Filters: Sheet metal housing arranged to be ducted in return-air duct connection to furnace; generates electrostatic charge; MERV 10 rating.

- F. HEPA Air Filter Units: Sheet metal housing with fan arranged to be ducted to return-air duct connection to furnace, with activated carbon prefilter[, carbon VOC,] and high-efficiency particulate air (HEPA) disposable filter. HEPA shall be as follows:

1. Standard: UL 586.
2. Rating: ASHRAE 52.2, 99.97 percent efficiency to 0.30-micrometer particle size.

2.6 AIR CLEANERS

- A. Electronic Air Cleaners: Packaged system, including sheet metal housing, prefilter, power supply, and automatic control device, arranged for mounting in return-air duct at furnace; equip with on-off and test switches and pilot light.

1. Standard: UL 586.
2. Rating: ASHRAE 52.2, particle size to 0.01 micrometer.
3. Static Pressure Drop: Maximum 0.14-inch wg (35 Pa) at 300-fpm (1.52-m/s) air velocity.

- B. Capacities and Characteristics:

1. Volts: <Insert value>.
2. Phase: <Insert value>.
3. Hertz: <Insert value>.
4. Minimum Circuit Ampacity: <Insert value>.
5. Maximum Overcurrent Protection: <Insert amperage>.

2.7 UV GERMICIDAL LIGHTS

- A. Description: Lighting unit in metal housing arranged for installation in supply-air duct and controlled to cycle on and off with furnace fan, with **[one][two]** 75-W UV-light bulb(s).

2.8 HUMIDIFIERS

- A. Minimum capacity rating indicated according to AHRI 610.
- B. Media-wheel bypass type with bypass damper and motor-driven media wheel in reservoir with float-valve level control; arranged for mounting on return duct or plenum with bypass connection to supply duct.
- C. Wetted-pad, continuous-drain, bypass type with bypass damper and water-flow control orifice; arranged for mounting on return duct or plenum with bypass connection to supply duct.
- D. Fan-powered, wetted-pad, continuous-drain type with water-flow control orifice and motor; arranged for mounting on duct or plenum.
- E. Pumped, fan-powered, wetted-pad type with reservoir-level control and pump and fan motors; arranged for mounting on duct or plenum.
- F. Steam type with electric heating element in stainless-steel reservoir with float-valve level control; arranged for attachment to duct or plenum and for control by humidistat.
- G. Comply with applicable requirements in ASHRAE 62.1.
- H. Capacities and Characteristics:
 - 1. Type: **[Steam][Media wheel][Wetted pad with reservoir][Wetted pad with continuous drain][Wetted-pad bypass]**.
 - 2. Steam Capacity: **<Insert lb/h (kg/h)>**.
 - 3. Water Connection Size: **<Insert NPS (DN)>**.
 - 4. Drain Connection Size: **<Insert NPS (DN)>**.
 - 5. Volts: **<Insert value>**.
 - 6. Phase: **<Insert value>**.
 - 7. Hertz: **<Insert value>**.
 - 8. Minimum Circuit Ampacity: **<Insert value>**.
 - 9. Maximum Overcurrent Protection: **<Insert amperage>**.

2.9 VENTILATION AIR HEAT EXCHANGERS

- A. Cabinet: Steel, with factory-installed interior insulation and manufacturer's standard factory finish. Fabricate with space for piping and electrical conduits.
- B. Heat-Recovery Device: Fixed-plate, polypropylene copolymer (high-density plastic) heat-exchanger plates evenly spaced and sealed and arranged for counter airflow.
- C. Supply and Exhaust Fans: Forward curved centrifugal with direct drive. Motors comply with requirements in Section 230500 "Common Work Results for HVAC."
- D. Filters: **1-inch- (25-mm-)** thick disposable type **[with ASHRAE 52.2 MERV rating of 6 or higher]**, in

galvanized-steel frame, mounted upstream of unit in both supply and exhaust airstreams.

- E. Wiring: Wire motors and controls so only external connections are required during installation.

2.10 REFRIGERATION COMPONENTS

- A. General Refrigeration Component Requirements:

1. Refrigeration compressor, coils, and specialties shall be designed to operate with CFC-free refrigerants.
2. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1.

- B. Refrigerant Coil: Copper tubes mechanically expanded into aluminum fins. Comply with AHRI 210/240. Match size with furnace. Include condensate drain pan with accessible drain outlet[**complying with ASHRAE 62.1**].

1. Refrigerant Coil Enclosure: Steel, matching furnace and evaporator coil, with access panel and flanges for integral mounting at or on furnace cabinet and galvanized sheet metal drain pan coated with black asphaltic base paint.

- C. Refrigerant Line Kits: Annealed-copper suction and liquid lines factory cleaned, dried, pressurized with nitrogen, sealed, and with suction line insulated. Provide in standard lengths for installation without joints, except at equipment connections.

1. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type I, [1/2 inch (13 mm)][1 inch (25 mm)]<Insert dimension> thick.

- D. Refrigerant Piping: Comply with requirements in Section 232300 "Refrigerant Piping."

- E. Air-Cooled Compressor-Condenser Unit:

1. Casing: Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed [**reciprocating**][or][**scroll**] type.
 - a. Crankcase heater.
 - b. [**Restrained vibration**][**Vibration**] isolation mounts for compressor.
 - c. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - d. Two-speed compressor motors shall have manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - e. Refrigerant Charge: [**R-407C**][**R-410A**]<Insert type>.
 - f. Refrigerant: R-407C or R-410A.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with liquid subcooler.
4. Heat-Pump Components: Reversing valve and low-temperature air cut-off thermostat.
5. Fan: Aluminum-propeller type, directly connected to motor.
6. Motor: Permanently lubricated, with integral thermal-overload protection.
7. Low Ambient Kit: Permits operation down to **45 deg F (7 deg C)**.
8. Mounting Base: Polyethylene.

- F. Capacities and Characteristics:

1. Refrigerant Coil:
 - a. Total Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Sensible Cooling Capacity: **<Insert Btu/h (kW)>**.
 - c. Heating Capacity: **<Insert Btu/h (kW)>**.
 - d. Maximum Air Pressure Drop: **<Insert inches wg (Pa)>**.
 - e. Condensate Drain Size: **<Insert NPS (DN)>**.
2. Compressor-Condenser Unit:
 - a. Cooling Energy Efficiency[**(EER)**][**(SEER)**]: **<Insert value>**.
 - b. Heating Coefficient of Performance: **<Insert value>**.
 - c. Volts: **<Insert value>**.
 - d. Phase: **<Insert value>**.
 - e. Hertz: **<Insert value>**.
 - f. Full-Load Amperes: **<Insert value>**.
 - g. Minimum Circuit Ampacity: **<Insert value>**.
 - h. Maximum Overcurrent Protection: **<Insert amperage>**.
 - i. Fan Motor Full-Load Amperes: **<Insert value>**.
 - j. Compressor Running-Load Amperes: **<Insert value>**.
 - k. Compressor Motor Full-Load Amperes: **<Insert value>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine factory-installed insulation before furnace installation. Reject units that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for gas[**and refrigerant**] piping systems to verify actual locations of piping connections before equipment installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install gas-fired furnaces and associated fuel and vent features and systems according to NFPA 54.
- B. Suspended Units: Suspend from structure using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
 1. Install seismic restraints to limit movement of furnace by resisting code-required seismic acceleration.
- C. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.
 1. Anchor furnace to substrate to resist code-required seismic acceleration.

- D. Controls: Install thermostats and humidistats at mounting height of **60 inches (1500 mm)** above floor.
- E. Wiring Method: Install control wiring in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal control wiring except in unfinished spaces.
- F. Install ground-mounted, compressor-condenser components on **4-inch- (100-mm-)** thick, reinforced concrete base; **4 inches (100 mm)** larger on each side than unit. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.
- G. Install ground-mounted compressor-condenser components on polyethylene mounting base.
- H. Install roof-mounted compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

3.3 PIPING CONNECTIONS

- A. Gas piping installation requirements are specified in **[Section 231123 "Facility Natural-Gas Piping."]****[Section 231126 "Facility Liquefied-Petroleum Gas Piping."]** Drawings indicate general arrangement of piping, fittings, and specialties. Connect gas piping with union or flange and appliance connector valve.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Water piping installation requirements are specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties. Connect water piping with union and ball valve.
- D. Vent Connection, Noncondensing, Gas-Fired Furnaces: Connect Type B vents to furnace vent connection and extend outdoors. Type B vents and their installation requirements are specified in Section 235123 "Gas Vents."
- E. Vent and Outside-Air Connection, Condensing, Gas-Fired Furnaces: Connect plastic piping vent material to furnace connections and extend outdoors. Terminate vent outdoors with a cap and in an arrangement that will protect against entry of birds, insects, and dirt.
 - 1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
 - 3. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - a. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. CPVC Piping: Join according to ASTM D2846/D2846M, Appendix.
 - c. PVC Pressure Piping: Join schedule number ASTM D1785 PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.
 - 4. Slope pipe vent back to furnace or to outside terminal.
- F. Connect refrigerant tubing kits to refrigerant coil in furnace and to air-cooled compressor-condenser unit.
 - 1. Flared Joints: Use ASME B16.26 fitting and flared ends, following procedures in CDA's "Copper Tube Handbook."

2. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
 3. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- G. Comply with requirements in Section 232300 "Refrigerant Piping" for installation and joint construction of refrigerant piping.

3.4 DUCTWORK CONNECTIONS

- A. Connect ducts to furnace with flexible connector. Comply with requirements in Section 233300 "Air Duct Accessories."

3.5 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

- A. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
1. Inspect for physical damage to unit casings.
 2. Verify that access doors move freely and are weathertight.
 3. Clean units and inspect for construction debris.
 4. Verify that all bolts and screws are tight.
 5. Adjust vibration isolation and flexible connections.
 6. Verify that controls are connected and operational.
- B. Adjust fan belts to proper alignment and tension.

- C. Start unit according to manufacturer's written instructions and complete manufacturer's operational checklist.
- D. Measure and record airflows.
- E. Verify proper operation of capacity control device.
- F. After startup and performance test, lubricate bearings[**and adjust belt tension**].

3.8 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set controls, burner, and other adjustments for optimum heating performance and efficiency. Adjust heat-distribution features, including shutters, dampers, and relays, to provide optimum heating performance and system efficiency.

3.9 CLEANING

- A. After completing installation, clean furnaces internally according to manufacturer's written instructions.
- B. Install new filters in each furnace within 14 days after Substantial Completion.

3.10 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Perform electrical test and visual and mechanical inspection.
 - 2. Leak Test: After installation, charge systems with refrigerant and test for leaks. Repair leaks, replace lost refrigerant, and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
 - 4. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
 - 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

3.11 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 23 54 16 13



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 54 16 13	23 54 13 00	Electric-Resistance Furnaces



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 54 16 16 - OIL-FIRED FURNACES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Oil-fired furnaces.
2. Thermostats and humidistats.
3. Air filters.
4. Air cleaners.
5. UV germicidal lights.
6. Humidifiers.
7. Ventilation air heat exchangers.
8. Refrigeration components.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals:

1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Product Data: For energy performance.
4. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
5. Product Data: For refrigerants, indicating compliance with refrigerant management practices.

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each furnace to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Furnace and accessories complete with controls.
 - b. Air filter.
 - c. Air cleaner.
 - d. UV germicidal light.
 - e. Humidifier.
 - f. Ventilation heat exchanger.
 - g. Refrigeration components.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Disposable Air Filters: Furnish **[two]<Insert number>** complete sets.
 2. Disposable Air-Cleaner Media: Furnish **[one]<Insert number>** complete set(s).
 3. Fan Belts: Furnish **[one]<Insert number>** set(s) for each furnace fan.
 4. Disposable Humidifier Media: Furnish **[one]<Insert number>** set(s).

1.6 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- C. Comply with NFPA 70.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period:
 1. Warranty Period, Commencing on Date of Substantial Completion:
 - a. Furnace Heat Exchanger: **[10 years][20 years][Lifetime]<Insert value>**.
 - b. Integrated Ignition and Blower Control Circuit Board: **[Five years]<Insert value>**.
 - c. Draft-Inducer Motor: **[Five years]<Insert value>**.
 - d. High-Efficiency Oil Furnace Burner: **[Three years]<Insert value>**.
 - e. Refrigeration Compressors: **[10 years][Lifetime]<Insert value>**.
 - f. Evaporator and Condenser Coils: **[Five years]<Insert value>**.
 - g. **<Insert components requiring extended warranty>**.



PART 2 - PRODUCTS

2.1 OIL-FIRED FURNACES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Adams Manufacturing Company]**
 2. **[Arcoaire; Carrier Global Corporation]**
 3. **[Bard Manufacturing Company]**
 4. **[Carrier Global Corporation]**
 5. **[Comfort-Aire; a division of Heat Controller, Inc.]**
 6. **[Comfortmaker; Carrier Global Corporation]**
 7. **[Dornback Furnace]**
 8. **[Heil; Carrier Global Corporation]**
 9. **[Lennox]**
 10. **[Luxaire; brand of Johnson Controls International plc, Building Solutions North America]**
 11. **[Ruud Air Conditioning Division]**
 12. **[Thermo Products, Inc.]**
 13. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 14. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Adams Manufacturing Company]**
 2. **[Arcoaire; Carrier Global Corporation]**
 3. **[Bard Manufacturing Company]**
 4. **[Carrier Global Corporation]**
 5. **[Comfort-Aire; a division of Heat Controller, Inc.]**
 6. **[Comfortmaker; Carrier Global Corporation]**
 7. **[Dornback Furnace]**
 8. **[Heil; Carrier Global Corporation]**
 9. **[Lennox]**
 10. **[Luxaire; brand of Johnson Controls International plc, Building Solutions North America]**
 11. **[Ruud Air Conditioning Division]**
 12. **[Thermo Products, Inc.]**
 13. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 14. **<Insert manufacturer's name>**
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency, and marked for intended location and application.
- D. Manufactured Units: Factory assembled, piped, wired, and tested; complying with UL 727 and with NFPA 31.

2.2 FURNACES

- A. Cabinet: **[Steel][Galvanized steel]**.
1. Cabinet interior around heat exchanger shall be factory-installed insulation.
 2. Lift-out panels shall expose burners and all other items requiring access for maintenance.
 3. Factory paint external cabinets in manufacturer's standard color.



4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Fan: Centrifugal, factory balanced, resilient mounted, [**direct drive**][**belt drive**][**direct or belt drive**][**drive type indicated on Drawings**].
 1. Fan Motors: Comply with requirements in Section 230500 "Common Work Results for HVAC."
 2. Special Motor Features:
 - a. Single speed, premium efficiency, as defined in Section 230500 "Common Work Results for HVAC," and with internal thermal protection and permanent lubrication.
 - b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
- C. Heat Exchanger: Welded steel with [**ceramic-fiber liner**][**refractory insert**] at the burner in the combustion chamber. Minimum **2-inch- (50-mm-)** diameter access ports in heat exchanger to permit access for cleaning.
- D. Burner: High-pressure atomizing type, with rubber-mounted, adjustable, combustion-air blower; integrated fuel pump; hinged, flame-inspection port; cadmium-sulfide flame sensor; electrodes; ignition transformer; and oil nozzle.
 1. Time-Delay Relay: Limits time for establishing main flame.
 2. Flame Sensor: Monitors flame and stops burner on flame failure.
 3. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
- E. Barometric Draft Regulator: Match furnace; for mounting in flue.
- F. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; and adjustable fan-on and fan-off timing; terminals for connection to accessories.
- G. Vent Materials: Comply with requirements in Section 235123 "Gas Vents" for Type B metal vents.
- H. Capacities and Characteristics:
 1. Airflow Configuration: [**Upflow**][**Counterflow**][**Horizontal**].
 2. Minimum Efficiency AFUE: **<Insert number>** percent.
 3. Minimum Thermal Efficiency: **<Insert number>** percent.
 4. Oil:
 - a. Input: **<Insert gph (L/s)>**.
 - b. Heat Output: **<Insert MBh (kW)>**.
 - c. Burner Motor:
 - 1) Size: **<Insert horsepower>**.
 - 2) Speed: **<Insert rpm>**.
 - d. Vent Size: **<Insert inches (mm)>**.
 5. Fan:
 - a. Airflow: **<Insert cfm (L/s)>**.
 - b. External Static Pressure: **<Insert inches wg (Pa)>**.
 - c. Motor:

- 1) Size: <Insert horsepower>.
 - 2) Speed: <Insert rpm>.
 - d. Volts: <Insert value>.
 - e. Phase: <Insert value>.
 - f. Hertz: <Insert value>.
 - g. Full-Load Amperes: <Insert value>.
 - h. Minimum Circuit Ampacity: <Insert value>.
 - i. Maximum Overcurrent Protection: <Insert amperage>.
6. Furnace Electrical Connection:
- a. Volts: <Insert value>.
 - b. Phase: <Insert value>.
 - c. Hertz: <Insert value>.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

2.3 THERMOSTATS AND HUMIDISTATS

- A. Controls shall comply with requirements in ASHRAE/IES 90.1, "Controls."
- B. Solid-State Thermostat: **[Wall-mounted][Freestanding][Wireless]**, programmable, microprocessor-based unit with **[automatic][manual]** switching from heating to cooling, preferential rate control, seven-day programmability with minimum of four temperature presets per day, **[vacation mode]**, and battery backup protection against power failure for program settings.
- C. Single-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.
- D. Two-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.
- E. Heating-Only Thermostat: **[Single][Two]**-stage, wall-mounted unit with fan on-automatic selector.
- F. Solid-State, Combination Thermostat and Humidistat: **[Wall-mounted][Freestanding][Wireless]**, programmable, microprocessor-based unit with automatic switching from heating to cooling and humidifying to dehumidifying, preferential rate control, seven-day programmability with minimum of four temperature presets per day, **[vacation mode]**, and battery backup protection against power failure for program settings.
- G. Humidistat: Adjustable, **[wall][duct]**-mounted unit.
- H. Control Wiring: Unshielded twisted-pair cabling.
1. No. 24 AWG, 100 ohm, four pair.
 2. Cable Jacket Color: **[Blue]<Insert color>**.

2.4 AIR FILTERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be**

incorporated into the Work include, but are not limited to, the following]:

1. [Aprilaire; Research Products Corp]
2. [Filtrete Home Filtration Products; a 3M brand]
3. [General Filters, Inc.]
4. [Permatron Corporation]
5. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Aprilaire; Research Products Corp]
2. [Filtrete Home Filtration Products; a 3M brand]
3. [General Filters, Inc.]
4. [Permatron Corporation]
5. <Insert manufacturer's name>

C. Washable Filters: 1-inch- (25-mm-) thick urethane pad.

D. Disposable Filters: [1-inch- (25-mm-)]<Insert dimension> thick fiberglass media[with ASHRAE 52.2 MERV rating of 6 or higher,] in sheet metal frame.

E. Charged Media Air Filters: Sheet metal housing arranged to be ducted in return-air duct connection to furnace; generates electrostatic charge; MERV 10 rating.

F. HEPA Air Filter Units: Sheet metal housing with fan arranged to be ducted to return-air duct connection to furnace, with activated carbon prefilter[, carbon VOC,] and high-efficiency particulate air (HEPA) disposable filter. HEPA shall be as follows:

1. Standard: UL 586.
2. Rating: ASHRAE 52.2, 99.97 percent efficiency to 0.30-micrometer particle size.

2.5 AIR CLEANERS

A. Electronic Air Cleaners: Packaged system, including sheet metal housing, prefilter, power supply, and automatic control device, arranged for mounting in return-air duct at furnace; equip with on-off and test switches and pilot light.

1. Standard: UL 586.
2. Rating: ASHRAE 52.2, particle size to 0.01 micrometer.
3. Static Pressure Drop: Maximum 0.14-inch wg (35 Pa) at 300-fpm (1.52-m/s) air velocity.

B. Capacities and Characteristics:

1. Volts: <Insert value>.
2. Phase: <Insert value>.
3. Hertz: <Insert value>.
4. Minimum Circuit Ampacity: <Insert value>.
5. Maximum Overcurrent Protection: <Insert amperage>.

2.6 UV GERMICIDAL LIGHTS

- A. Description: Lighting unit in metal housing arranged for installation in supply-air duct and controlled to cycle on and off with furnace fan, with **[one][two]** 75-W UV light bulb(s).

2.7 HUMIDIFIERS

- A. Minimum capacity rating indicated according to AHRI 610.
- B. Media-wheel bypass type with bypass damper and motor-driven media wheel in reservoir with float-valve level control; arranged for mounting on return duct or plenum with bypass connection to supply duct.
- C. Wetted-pad, continuous-drain, bypass type with bypass damper and water-flow control orifice; arranged for mounting on return duct or plenum with bypass connection to supply duct.
- D. Fan-powered, wetted-pad, continuous-drain type with water-flow control orifice and motor; arranged for mounting on duct or plenum.
- E. Pumped, fan-powered, wetted-pad type with reservoir-level control and pump and fan motors; arranged for mounting on duct or plenum.
- F. Steam type with electric heating element in stainless-steel reservoir with float-valve level control; arranged for attachment to duct or plenum and for control by humidistat.
- G. Comply with applicable requirements in ASHRAE 62.1.
- H. Capacities and Characteristics:
 - 1. Type: **[Steam][Media wheel][Wetted pad with reservoir][Wetted pad with continuous drain][Wetted-pad bypass]**.
 - 2. Steam Capacity: **<Insert lb/h (kg/h)>**.
 - 3. Water Connection Size: **<Insert NPS (DN)>**.
 - 4. Drain Connection Size: **<Insert NPS (DN)>**.
 - 5. Volts: **<Insert value>**.
 - 6. Phase: **<Insert value>**.
 - 7. Hertz: **<Insert value>**.
 - 8. Minimum Circuit Ampacity: **<Insert value>**.
 - 9. Maximum Overcurrent Protection: **<Insert amperage>**.

2.8 VENTILATION AIR HEAT EXCHANGERS

- A. Cabinet: Steel, with factory-installed interior insulation and manufacturer's standard factory finish. Fabricate with space for piping and electrical conduits.
- B. Heat-Recovery Device: Fixed-plate, polypropylene copolymer (high-density plastic) heat-exchanger plates evenly spaced and sealed and arranged for counter airflow.
- C. Supply and Exhaust Fans: Forward curved centrifugal with direct drive. Motors comply with requirements in Section 230500 "Common Work Results for HVAC."
- D. Filters: **1-inch- (25-mm-)** thick disposable type **[with ASHRAE 52.2 MERV rating of 6 or higher]**, in galvanized-steel frame, mounted upstream of unit in both supply and exhaust airstreams.

- E. Wiring: Wire motors and controls so only external connections are required during installation.

2.9 REFRIGERATION COMPONENTS

A. General Refrigeration Component Requirements:

1. Refrigeration compressor, coils, and specialties shall be designed to operate with CFC-free refrigerants.
2. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1.

B. Refrigerant Coil: Copper tubes mechanically expanded into aluminum fins. Comply with AHRI 210/240. Match size with furnace. Include condensate drain pan with accessible drain outlet[**complying with ASHRAE 62.1**].

1. Refrigerant Coil Enclosure: Steel, matching furnace and evaporator coil, with access panel and flanges for integral mounting at or on furnace cabinet and galvanized sheet metal drain pan coated with black asphaltic base paint.

C. Refrigerant Line Kits: Annealed-copper suction and liquid lines factory cleaned, dried, pressurized with nitrogen, sealed, and with suction line insulated. Provide in standard lengths for installation without joints, except at equipment connections.

1. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type I, [1/2 inch (13 mm)][1 inch (25 mm)]<Insert dimension> thick.

D. Refrigerant Piping: Comply with requirements in Section 232300 "Refrigerant Piping."

E. Air-Cooled Compressor-Condenser Unit:

1. Casing: Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed [**reciprocating**][or][**scroll**] type.
 - a. Crankcase heater.
 - b. [**Restrained vibration**][**Vibration**] isolation mounts for compressor.
 - c. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - d. Two-speed compressor motors shall have manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - e. Refrigerant Charge: [**R-407C**][**R-410A**]<Insert type>.
 - f. Refrigerant: R-407C or R-410A.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with liquid subcooler.
4. Heat-Pump Components: Reversing valve and low-temperature air cut-off thermostat.
5. Fan: Aluminum-propeller type, directly connected to motor.
6. Motor: Permanently lubricated, with integral thermal-overload protection.
7. Low Ambient Kit: Permits operation down to **45 deg F (7 deg C)**.
8. Mounting Base: Polyethylene.

F. Capacities and Characteristics:

1. Refrigerant Coil:

- a. Total Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Sensible Cooling Capacity: **<Insert Btu/h (kW)>**.
 - c. Heating Capacity: **<Insert Btu/h (kW)>**.
 - d. Maximum Air Pressure Drop: **<Insert inches wg (Pa)>**.
 - e. Condensate Drain Size: **<Insert NPS (DN)>**.
2. Compressor-Condenser Unit:
- a. Cooling Energy Efficiency[**(EER)**][**(SEER)**]: **<Insert value>**.
 - b. Heating Coefficient of Performance: **<Insert value>**.
 - c. Volts: **<Insert value>**.
 - d. Phase: **<Insert value>**.
 - e. Hertz: **<Insert value>**.
 - f. Full-Load Amperes: **<Insert value>**.
 - g. Minimum Circuit Ampacity: **<Insert value>**.
 - h. Maximum Overcurrent Protection: **<Insert amperage>**.
 - i. Fan Motor Full-Load Amperes: **<Insert value>**.
 - j. Compressor Running-Load Amperes: **<Insert value>**.
 - k. Compressor Motor Full-Load Amperes: **<Insert value>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine factory-installed insulation before furnace installation. Reject units that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for oil[**and refrigerant**] piping systems to verify actual locations of piping connections before equipment installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install oil-fired furnaces and associated fuel and vent piping according to NFPA 31.
- B. Suspended Units: Suspend from structure using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
 - 1. Install seismic restraints to limit movement of furnace by resisting code-required seismic acceleration.
- C. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.
 - 1. Anchor furnace to substrate to resist code-required seismic acceleration.
- D. Controls: Install thermostats and humidistats at mounting height of **60 inches (1500 mm)** above floor.



- E. Wiring Method: Install control wiring in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal control wiring except in unfinished spaces.
- F. Install ground-mounted, compressor-condenser components on **4-inch- (100-mm-)** thick, reinforced concrete base; **4 inches (100 mm)** larger on each side than unit. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.
- G. Install ground-mounted compressor-condenser components on polyethylene mounting base.
- H. Install roof-mounted compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

3.3 CONNECTIONS

- A. Oil piping installation requirements are specified in Section 231113 "Facility Fuel-Oil Piping." Drawings indicate general arrangement of piping, fittings, and specialties. Connect oil piping with union or flange and **[ball][gate]** valve.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Water piping installation requirements are specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties. Connect water piping with union and ball valve.
- D. Vent Connections: Connect Type L vents to furnace vent connection and extend outdoors. Type L vents and their installation requirements are specified in Section 235123 "Gas Vents."
- E. Connect ducts to furnace with flexible connector. Comply with requirements in Section 233300 "Air Duct Accessories."
- F. Connect refrigerant tubing kits to refrigerant coil in furnace and to air-cooled, compressor-condenser unit.
 - 1. Flared Joints: Use ASME B16.26 fitting and flared ends, following procedures in CDA's "Copper Tube Handbook."
 - 2. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
 - 3. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- G. Comply with requirements in Section 232300 "Refrigerant Piping" for installation and joint construction of refrigerant piping.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Perform electrical test and visual and mechanical inspection.
 - 2. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
 4. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

3.5 STARTUP SERVICE

- A. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
1. Inspect for physical damage to unit casings.
 2. Verify that access doors move freely and are weathertight.
 3. Clean units and inspect for construction debris.
 4. Verify that all bolts and screws are tight.
 5. Adjust vibration isolation and flexible connections.
 6. Verify that controls are connected and operational.
- B. Adjust fan belts to proper alignment and tension.
- C. Start unit according to manufacturer's written instructions and complete manufacturer's operational checklist.
- D. Measure and record airflows.
- E. Verify proper operation of capacity control device.
- F. After startup and performance test, lubricate bearings[**and adjust belt tension**].

3.6 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set controls, burner, and other adjustments for optimum heating performance and efficiency. Adjust heat-distribution features, including shutters, dampers, and relays, to provide optimum heating performance and system efficiency.

3.7 CLEANING

- A. After completing installation, clean furnaces internally according to manufacturer's written instructions.
- B. Install new filters in each furnace within 14 days after Substantial Completion.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units. Refer to Section 017900 "Demonstration and Training."



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

END OF SECTION 23 54 16 16



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 54 16 16	23 54 13 00	Electric-Resistance Furnaces
23 54 19 00	23 54 13 00	Electric-Resistance Furnaces



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 55 23 13 - LOW-INTENSITY, GAS-FIRED, RADIANT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Forced-draft heaters.
2. Draft-induced heaters.
3. Multiple-burner heaters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Signed, sealed, and prepared by or under the supervision of a qualified professional engineer.
2. Include plans, elevations, sections, and **[mounting][attachment]** details.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail fabrication and assembly of high-intensity, gas-fired, radiant heaters, as well as procedures and diagrams.
5. Include diagrams for power[, **signal, and control**] wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which equipment will be attached.
2. Gas piping to heater installations
3. Thermostats and wiring to heaters.
4. Heater locations and clearance requirements.
5. Other suspended ceiling components including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Sprinklers.
 - d. **<Insert item>**.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's special warranties.



1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gas-fired, radiant heaters to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Igniter: **[One]<Insert number>** hot-surface burner igniter(s) for each style of high-intensity, gas-fired, radiant heater furnished.

1.6 WARRANTY

- A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of radiant heaters that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: All warranty periods listed below are from date of Substantial Completion.
 - a. Burner Assembly: **[Three][Five][10]<Insert number>** years.
 - b. Combustion and Emitter Tubes: **[Two][Three][Five]<Insert number>** years.
 - c. Heater Controls: One **<Insert number>** year(s).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. CSA certified, with CSA Seal and certification number clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.
- B. UL listed and labeled, with UL label clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 FORCED-DRAFT HEATERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[ABB, Electrification Business]**
 - 2. **[Calcana Industries Ltd.]**
 - 3. **[Combustion Research Corporation]**
 - 4. **[Detroit Radiant Products Company]**
 - 5. **[Roberts-Gordon, Inc]**
 - 6. **[Schwank Inc.]**

7. [Solaronics, Inc.]
 8. [Space-Ray; a division of Gas-Fired Products Inc.]
 9. [Sterling HVAC Products; a Mestek company]
 10. [Superior Radiant Products Ltd.]
 11. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [ABB, Electrification Business]
 2. [Calcana Industries Ltd.]
 3. [Combustion Research Corporation]
 4. [Detroit Radiant Products Company]
 5. [Roberts-Gordon, Inc]
 6. [Schwank Inc.]
 7. [Solaronics, Inc.]
 8. [Space-Ray; a division of Gas-Fired Products Inc.]
 9. [Sterling HVAC Products; a Mestek company]
 10. [Superior Radiant Products Ltd.]
 11. <Insert manufacturer's name>
- C. Description: Factory-assembled, [indoor][outdoor], overhead-mounted, electrically controlled, low-intensity, infrared radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup.
- D. Fuel Type: Design burner for [natural][propane] gas having characteristics same as those of gas available at Project site.
- E. Burner Assembly:
1. Combustion-Air Inlet:
 - a. Non-ducted, unvented.
 - b. Ducted horizontal to outdoors through sidewall with vent caps.
 - c. Ducted vertical to outdoors through roof with vent caps.
 2. Burner Control Housing: [Stainless steel][Corrosion-resistant, aluminized steel][Steel].
 - a. Totally enclosed with [stainless steel][steel] access cover.
 - b. Sight glass for visual inspection of burner.
 - c. Finish: [Enameled finish][or][powder-coated finish].
 3. Burner: [Stainless steel][One-piece cast iron].
 4. Ignition System: [Silicon carbide hot-surface igniter][Direct spark][24/25-V ac][115/120-V ac] with flame rod sensing capabilities[and self-diagnostic control module].
 5. Combustion Blower Fan: Dynamically balanced, direct-driven, forward-curved fan with [cast-aluminum-alloy][stainless steel]<Insert material> impeller and [aluminized-]steel housing, with a minimum temperature rating of 450 deg F (232 deg C).
 6. Motors: General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor: Resilient-mounted, capacitor-start-capacitor-run type with sealed ball bearings; totally enclosed, nonventilated type with internal thermal protection.
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

- F. Combustion Chamber: **4-inch- (100-mm-)** diameter, **[12][16]-gauge, [aluminized-][titanium-coated aluminized-][stainless][hot-rolled-]** steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish. Chambers shall be equipped with sight glass for burner and pilot flame observation.
- G. Emitter Tube: **[4-inch- (100-mm-)][3-inch- (76-mm-)]** diameter, **[12][16]-gauge, [aluminized-][hot-rolled-][stainless][titanium-coated aluminized-]** steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish. **[Emitter tubing shall be equipped with baffles to maximize heating efficiency.]**
 1. Tubing Connections: **[Stainless steel threaded couplings][Interlocking flare joints with stainless steel draw bolts][Compression couplings made from aluminized or stainless steel]**.
 2. **[90][180]-degree-bend** emitter steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish.
 3. Exhaust Vent Termination: **[Vertical through roof][Horizontal though side wall]** with vent caps.
- H. Reflector: **[Polished aluminum][Polished stainless steel][High-grade steel with a heat- and corrosion-resistant, hot-bonded, aluminum-silicon alloy coating]**, with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Reflectors or entire heater shall accommodate rotational adjustment from horizontal to a minimum 30-degree tilt from vertical.
- I. Accessories:
 1. Reflector Extension Shields: Same material as reflectors, arranged for fixed connection to lower reflector lip and rigid support to provide 100 percent cutoff of direct radiation from tubing at angles greater than 30 degrees from vertical.
 2. Protective grilles mounted to reflectors to protect emitter tubing.
 3. Stainless steel flexible connector with manual valve for gas supply.
 4. Hanger chain with "S" hooks.
 5. **3/16-inch- (5-mm-)** diameter, **[galvanized][aluminized]-steel** wire tubing hangers and reflector supports.
 6. Rigid mounting kits.
 7. Outdoor use conversion kit.
 8. Clearance warning plaque.
- J. Capacities and Characteristics:
 1. Gas Input: **<Insert Btu/h (kW)>**.
 2. Gas Output: **<Insert Btu/h (kW)>**.
 3. Fuel-Supply Connection: **<Insert inches (mm)>**.
 4. Combustion-Air Fan Motor Size: **<Insert value> hp**.
 - a. Volts: **[120][208][230]<Insert value> V**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.3 DRAFT-INDUCED HEATERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide**

products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [Combustion Research Corporation]
2. [Detroit Radiant Products Company]
3. [Roberts-Gordon, Inc]
4. [Schwank Inc.]
5. [Solaronics, Inc.]
6. [Space-Ray; a division of Gas-Fired Products Inc.]
7. [Superior Radiant Products Ltd.]
8. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Combustion Research Corporation]
2. [Detroit Radiant Products Company]
3. [Roberts-Gordon, Inc]
4. [Schwank Inc.]
5. [Solaronics, Inc.]
6. [Space-Ray; a division of Gas-Fired Products Inc.]
7. [Superior Radiant Products Ltd.]
8. <Insert manufacturer's name>

- C. Description: Factory-assembled, [indoor][outdoor], overhead-mounted, electrically controlled, low-intensity, infrared radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup.

- D. Fuel Type: Design burner for [natural][propane] gas having characteristics same as those of gas available at Project site.

- E. Burner Assembly:

1. Combustion-Air Inlet:
 - a. Non-ducted, unvented.
 - b. Ducted horizontal to outdoors through sidewall with vent caps.
 - c. Ducted vertical to outdoors through roof with vent caps.
2. Burner Control Housing: [Stainless steel][Corrosion-resistant, aluminized steel][Steel].
 - a. Totally enclosed with [stainless steel][steel] access cover.
 - b. Sight glass for visual inspection of burner.
 - c. Finish: [Enameled finish][or][powder-coated finish].
3. Burner: [Stainless steel][One-piece cast iron].
4. Ignition System: [Silicon carbide hot-surface igniter][Direct spark][24/25-V ac][115/120-V ac] with flame rod sensing capabilities[and self-diagnostic control module].
5. Combustion Blower Fan: Dynamically balanced, direct-driven, forward-curved fan with [cast-aluminum-alloy][stainless steel]<Insert material> impeller and [aluminized-]steel housing, with a minimum temperature rating of 450 deg F (232 deg C).
6. Motors: General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor: Resilient-mounted, capacitor-start-capacitor-run type with sealed ball bearings; totally enclosed, nonventilated type with internal thermal protection.



- b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- F. Combustion Chamber: **4-inch- (100-mm-)** diameter, **[12][16]-gauge, [aluminized-][titanium-coated aluminized-][stainless][hot-rolled-]** steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish. Chambers shall be equipped with sight glass for burner and pilot flame observation.
- G. Emitter Tube: **[4-inch- (100-mm-)][3-inch- (76-mm-)]** diameter, **[12][16]-gauge, [aluminized-][hot-rolled-][stainless][titanium-coated aluminized-]** steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish. **[Emitter tubing shall be equipped with baffles to maximize heating efficiency.]**
 - 1. Tubing Connections: **[Stainless steel threaded couplings][Interlocking flare joints with stainless steel draw bolts][Compression couplings made from aluminized or stainless steel]**.
 - 2. **[90][180]-degree-bend** emitter steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish.
- H. Vacuum Exhaust Fan: Dynamically balanced, direct-driven, **[cast-aluminum-alloy][stainless steel]** impeller in aluminized-steel housing, isolated from emitter tubing exhaust system by high-temperature flexible vibration isolation connector. Fan and connector to have a minimum temperature rating of **450 deg F (232 deg C)**.
 - 1. Motors: General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor: Resilient-mounted, capacitor-start-capacitor-run type with sealed ball bearings; totally enclosed, nonventilated type with internal thermal protection.
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Balancing Dampers: Plate type, mounted in cast, double-flange fitting with vacuum test plug.
 - 3. Filter: Cartridge type for mounting on burner housing.
 - 4. Exhaust Vent Termination: **[Vertical through roof][Horizontal though side-wall]** with vent caps.
- I. Reflector: **[Polished aluminum][Polished stainless steel][High-grade steel with a heat- and corrosion-resistant, hot-bonded, aluminum-silicon alloy coating]**, with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Reflectors or entire heater shall accommodate rotational adjustment from horizontal to a minimum 30-degree tilt from vertical.
- J. Accessories:
 - 1. Reflector Extension Shields: Same material as reflectors, arranged for fixed connection to lower reflector lip and rigid support to provide 100 percent cutoff of direct radiation from tubing at angles greater than 30 degrees from vertical.
 - 2. Protective grilles mounted to reflectors to protect emitter tubing.
 - 3. Stainless steel flexible connector with manual valve for gas supply.
 - 4. Hanger chain with "S" hooks.
 - 5. **3/16-inch- (5-mm-)** diameter, **[galvanized][aluminized]-steel** wire tubing hangers and reflector supports.
 - 6. Rigid mounting kits.
 - 7. Outdoor use conversion kit.
 - 8. Clearance warning plaque.

K. Capacities and Characteristics:

1. Gas Input: **<Insert Btu/h (kW)>**.
2. Gas Output: **<Insert Btu/h (kW)>**.
3. Fuel-Supply Connection: **<Insert inches (mm)>**.
4. Combustion-Air Fan Motor Size: **<Insert value>** hp.
 - a. Volts: **[120][208][230]<Insert value>** V.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.
5. Vacuum Exhaust Fan Motor Size: **<Insert value>** hp.
 - a. Volts: **[120][208][230]<Insert value>** V.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.4 MULTIPLE-BURNER HEATERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Combustion Research Corporation]**
 2. **[Detroit Radiant Products Company]**
 3. **[Roberts-Gordon, Inc]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Combustion Research Corporation]**
 2. **[Detroit Radiant Products Company]**
 3. **[Roberts-Gordon, Inc]**
 4. **<Insert manufacturer's name>**
- C. Description: Factory-assembled, **[indoor][outdoor]**, overhead-mounted, electrically controlled, low-intensity, infrared radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup.
- D. Fuel Type: Design burner for **[natural][propane]** gas having characteristics same as those of gas available at Project site.
- E. Burner Assembly: .
1. Combustion-Air Inlet:
 - a. Non-ducted, unvented.
 - b. Ducted horizontal to outdoors through sidewall with vent caps.

- c. Ducted vertical to outdoors through roof with vent caps.
 2. Burner Control Housing: **[Stainless steel][Corrosion-resistant, aluminized steel][Steel]**.
 - a. Totally enclosed with **[stainless steel][steel]** access cover.
 - b. Sight glass for visual inspection of burner.
 - c. Finish: **[Enameled finish][or][powder-coated finish]**.
 3. Burner: **[Stainless steel][One-piece cast iron]**.
 4. Ignition System: **[Silicon carbide hot-surface igniter][Direct spark][24/25-V ac][115/120-V ac]** with flame rod sensing capabilities **[and self-diagnostic control module]**.
 5. Combustion Blower Fan: Dynamically balanced, direct-driven, forward-curved fan with **[cast-aluminum-alloy][stainless steel]<Insert material>** impeller and **[aluminized-]**steel housing, with a minimum temperature rating of **450 deg F (232 deg C)**.
 6. Motors: General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor: Resilient-mounted, capacitor-start-capacitor-run type with sealed ball bearings; totally enclosed, nonventilated type with internal thermal protection.
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- F. Combustion Chamber: **4-inch- (100-mm-)** diameter, **[12][16]-gauge, [aluminized-][titanium-coated aluminized-][stainless][hot-rolled-]** steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish. Chambers shall be equipped with sight glass for burner and pilot flame observation.
- G. Emitter Tube: **[4-inch- (100-mm-)][3-inch- (76-mm-)]** diameter, **[12][16]-gauge, [aluminized-][hot-rolled-][stainless][porcelain-lined-][titanium-coated aluminized-]** steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish. **[Emitter tubing shall be equipped with baffles to maximize heating efficiency.]**
1. Tubing Connections: **[Stainless steel threaded couplings][Interlocking flare joints with stainless steel draw bolts][Compression couplings made from aluminized or stainless steel]**.
 2. **[90-degree bends][180-degree bends][Tee fittings][Cross fittings]** made from **[stainless steel]** with corrosion-resistant, high-temperature black coating.
 3. Condensing Tubing: **4-inch- (100-mm-)** diameter, stainless steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish.
- H. Vacuum Exhaust Fan: Dynamically balanced, direct-driven, **[cast-aluminum-alloy][stainless steel]** impeller in aluminized-steel housing, isolated from emitter tubing exhaust system by high-temperature flexible vibration isolation connector. Fan and connector to have a minimum temperature rating of **450 deg F (232 deg C)**.
1. See **[Section 230548 "Vibration and Seismic Controls for HVAC"]****[Section 230548.13 "Vibration Controls for HVAC"]** for mounting vacuum exhaust fan.
 2. Motors: General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor: Resilient-mounted, capacitor-start-capacitor-run type with sealed ball bearings; totally enclosed, nonventilated type with internal thermal protection.
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

3. Balancing Dampers: Plate type, mounted in cast, double-flange fitting with vacuum test plug.
 4. Filter: Cartridge type for mounting on burner housing.
 5. Exhaust Vent Termination: **[Vertical through roof][Horizontal through side wall]** with vent caps.
- I. Reflector: **[Polished aluminum][Polished stainless steel][High-grade steel with a heat- and corrosion-resistant, hot-bonded, aluminum-silicon alloy coating]**, with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Reflectors shall accommodate rotational adjustment from horizontal to a minimum 30-degree tilt from vertical.
- J. Accessories:
1. Reflector Extension Shields: Same material as reflectors, arranged for fixed connection to lower reflector lip and rigid support to provide 100 percent cutoff of direct radiation from tubing at angles greater than 30 degrees from vertical.
 2. Protective grilles mounted to reflectors to protect emitter tubing.
 3. Stainless steel flexible connector with manual valve for gas supply.
 4. Hanger chain with "S" hooks.
 5. **3/16-inch- (5-mm-)** diameter, **[galvanized][aluminized]**-steel wire tubing hangers and reflector supports.
 6. Rigid mounting kits.
 7. Outdoor use conversion kit.
 8. Clearance warning plaque.
- K. Capacities and Characteristics:
1. Gas Input: **<Insert Btu/h (kW)>**.
 2. Gas Output: **<Insert Btu/h (kW)>**.
 3. Fuel-Supply Connection: **<Insert inches (mm)>**.
 4. Combustion-Air Fan Motor Size: **<Insert value>** hp.
 - a. Volts: **[120][208][230]<Insert value>** V.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.
 5. Vacuum Exhaust Fan Motor Size: **<Insert value>** hp.
 - a. Volts: **[120][208][230]<Insert value>** V.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.5 CONTROLS AND SAFETIES

- A. Gas Control Valve: **[Single][Two]**-stage, regulated redundant 24-V ac gas valve that contains pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
- B. Failure Safeguards: 100 percent shutoff of gas flow in the event of flame or power failure.



- C. Prepurge of [15][30][45] seconds of air control system prior to burner ignition.
- D. Safety lockout of burner after [three consecutive ignition failures][flame is not reestablished within trial ignition period].
- E. Blocked Vent Safety: Differential pressure switch in burner safety circuit to stop burner operation with high discharge or suction pressure.
- F. Control Panel Interlock: Stops burner if panel is open.
- G. Indicator Lights: ["Airflow-on"][and]["burner-on"] indicator lights.
- H. Thermostat:
 - 1. Devices and wiring are specified in Section 230923.27 "Temperature Instruments."
 - 2. Single-stage, wall-mounted type with **50 to 90 deg F (10 to 32 deg C)** operating range and fan on switch.
 - a. Control transformer, integrally mounted.
 - 3. Two-stage, wall-mounted type with **50 to 90 deg F (10 to 32 deg C)** operating range and fan on switch.
 - a. Control transformer, integrally mounted.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine structures, substrates, areas and conditions, with Installer present, for compliance with requirements for installation tolerances, required clearances, and other conditions affecting performance of the Work.
- B. Examine roughing-in for fuel-gas piping to verify actual locations of piping connections before equipment installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Installation: Install gas-fired, radiant heaters and associated gas features and systems according to [NFPA 54][CSA B149.1].
- B. Suspended Units: [Suspend from substrate using chain hanger kits and building attachments][Mount to substrate using manufacturer's rigid mounting kits or custom fabricated brackets].
 - 1. Restrain the unit to resist seismic acceleration. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

- C. Maintain manufacturers' recommended clearances for combustibles.

3.3 CONNECTIONS

- A. Gas Piping: Comply with **[Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping."]** Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.
 1. Gas Connections: Connect gas piping to radiant heaters according to **[NFPA 54][CSA B149.1]**.
- B. Where installing piping adjacent to gas-fired, radiant heaters, allow space for service and maintenance.
- C. Vent Connections: Comply with Section 233113 "Metal Ducts" and with Section 235123 "Gas Vents."
- D. Electrical Connections: Comply with applicable requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 1. Install electrical devices furnished with heaters but not specified to be factory mounted.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 2. Verify bearing lubrication.
 3. Verify proper motor rotation.
 4. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- C. Gas-fired, radiant heaters will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial-temperature set points.
- B. Adjust burner and other unit components for optimum heating performance and efficiency.



3.6 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain gas-fired, radiant heaters.

END OF SECTION 23 55 23 13



SECTION 23 55 23 13A - RADIANT-HEATING ELECTRIC PANELS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes prefabricated radiant-heating electric panels.
- B. Related Requirements:
 - 1. Section 238213 "Valance Heating and Cooling Units" for factory-fabricated electric heating panels for ceiling and wall applications.
 - 2. Section 238313 "Radiant-Heating Electric Cables."

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For electric heating panels.
 - 1. Include plans, sections, details, and attachments to other work.
 - 2. Include diagrams for power, signal, and control wiring.
- C. Samples for Initial Selection: For units with factory-applied color finishes.
- D. Samples for Verification for Radiant-Panel Finishes: **[12 by 12 inches (300 by 300 mm)]<Insert size>**.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Method of attaching hangers to building structure.
 - 3. Structural members to which heating panels and suspension systems will be attached.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Items installed in finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.
 - g. **<Insert item>**.
- B. Field quality-control reports.



- C. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For electric heating panels to include in operation and maintenance manuals.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace electric heating panels that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: **[Three][Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR RADIANT-HEATING ELECTRIC PANELS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 PREFABRICATED RADIANT-HEATING ELECTRIC PANELS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Berko; Marley Engineered Products]**
 - 2. **[QMark; Marley Engineered Products]**
 - 3. **[SSHC, Inc]**
 - 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Berko; Marley Engineered Products]**
 - 2. **[QMark; Marley Engineered Products]**
 - 3. **[SSHC, Inc]**
 - 4. **<Insert manufacturer's name>**
- C. Description: Sheet-metal-enclosed panel with heating element suitable for **[lay-in installation flush with T-bar ceiling grid][surface mounting][recessed mounting]**. Comply with UL 2021.
 - 1. Panel: Minimum **0.0276-inch- (0.7-mm-)** thick, galvanized sheet steel back panel riveted to minimum **0.0396-inch- (1.0-mm-)** thick, galvanized sheet steel front panel with fused-on crystalline surface.
 - 2. Heating Element:
 - a. Powdered graphite sandwiched between sheets of electric insulation.

- b. Insulated resistive wires.
 - 3. Electrical Connections: Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.
 - 4. Exposed-Side Panel Finish:
 - a. Apply silk-screened finish to match appearance of Architect-selected acoustical ceiling tiles.
 - b. Factory prime coated, ready for field painting.
 - c. Baked-enamel finish in manufacturer's **[standard][custom]** paint color as selected by Architect.
 - 5. Surface-Mounted Trim: Sheet metal with baked-enamel finish in manufacturer's **[standard][custom]** paint color as selected by Architect.
- D. Wall Thermostat: Bimetal, sensing elements calibrated from **55 to 90 deg F (13 to 32 deg C)**; with contacts suitable for **[low][line]**-voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.
- E. Capacities and Characteristics:
 - 1. Nominal Panel Size: **[24 by 24 inches (600 by 600 mm)][24 by 36 inches (600 by 900 mm)][24 by 48 inches (600 by 1200 mm)][24 by 60 inches (600 by 1500 mm)]<Insert custom size>**.
 - 2. Heating Capacity: **[250][375][500][570][625][750][950]<Insert value> W**.
 - 3. Electrical Characteristics for Single-Point Connection:
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and substrates to receive electric heating panels for compliance with requirements for installation tolerances and other conditions affecting performance.
 - 1. Ensure surfaces in contact with electric heating panels are free of burrs and sharp protrusions.
 - 2. Ensure surfaces and substrates are level and plumb.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install radiant-heating panels level and plumb.
- B. Support for Radiant-Heating Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.

1. Install a minimum of four ceiling-support-system rods or wires for each panel. Locate not more than **6 inches (150 mm)** from panel corners.
 2. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
 3. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support panels independently with at least two **3/4-inch (19-mm)** metal channels spanning and secured to ceiling tees.
 4. Install at least one independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of the panel at a safety factor of 3.
- C. Verify locations of thermostats with Drawings and room details before installation. Install devices **[48 inches (1220 mm)][60 inches (1525 mm)]<Insert dimension>** above finished floor.

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 1. Operate electric-heating elements through each stage to verify proper operation and electrical connections.
 2. Test and adjust controls and safeties.
- D. Radiant-heating electric panels will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.5 PROTECTION

- A. Protect installed radiant-heating electric panels from damage during construction.
- B. Remove and replace damaged radiant-heating electric panels.

END OF SECTION 23 55 23 13A



SECTION 23 55 33 00 - OIL-FIRED UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Oil-fired unit heaters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of oil-fired unit heater.

1. Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: For oil-fired unit heaters[; **signed and sealed by a qualified professional engineer**]. Include plans, elevations, sections, and attachment details.

1. Prepare by or under the supervision of a qualified professional engineer detailing fabrication and assembly of oil-fired unit heaters, as well as procedures and diagrams.
2. Design Calculations: Calculate requirements for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Include diagrams for power[, **signal, and control**] wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which equipment will be attached.
2. Items penetrating roof and the following:
 - a. Vent and oil piping rough-ins and connections.
 - b. **<Insert item>**.

B. Seismic Qualification Certificates: For oil-fired unit heaters, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

- D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For oil-fired unit heaters to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Fan Belts: **[One]<Insert number>** for each belt-driven fan size.

1.6 QUALITY ASSURANCE

- A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of oil-fired unit heater that fails in materials or workmanship within specified warranty period.

- 1. Warranty Period: **[Two][Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Oil-fired unit heaters shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. Seismic Fabrication Requirements: Fabricate and reinforce suspension attachments of oil-fired unit heaters, accessories mountings, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when oil-fired unit heater is anchored to building structure.
 - 2. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Capacities and Characteristics:

1. Oil Input: **<Insert gph (L/s)>**.
2. Heat Output: **<Insert Btu/h (kW)>**.
3. Annual Fuel Utilization Efficiency: **[80]<Insert number>** percent.
4. Minimum Airflow: **<Insert cfm (L/s)>**.
5. External Static Pressure: **<Insert inches wg (kPa)>**.
6. Motor Enclosure: Totally enclosed, fan cooled.
7. Electrical Characteristics:
 - a. Motor Size: **<Insert horsepower>**.
 - b. Motor Speed: **<Insert number>** rpm.
 - c. Volts: **[120][208][230]<Insert value>**.
 - d. Phase: **[Single][Poly]**.
 - e. Hertz: 60.
 - f. Full-Load Amperes: **<Insert value>**.
 - g. Minimum Circuit Ampacity: **<Insert value>**.
 - h. Maximum Overcurrent Protection: **<Insert amperage>**.

2.2 OIL-FIRED UNIT HEATERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Modine Manufacturing Company]**
 2. **[REZNOR, a brand of Nortek Global HVAC]**
 3. **[Sterling HVAC Products; a Mestek company]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Modine Manufacturing Company]**
 2. **[REZNOR, a brand of Nortek Global HVAC]**
 3. **[Sterling HVAC Products; a Mestek company]**
 4. **<Insert manufacturer's name>**
- C. Description: Factory assembled, piped, and wired, and complying with UL 731.
- D. Housing: Steel, with inserts for suspension mounting rods.
 1. External Casings and Cabinets: **[Baked enamel][Powder coating]** over corrosion-resistant-treated surface.
 2. Discharge Louvers: Independently adjustable, **[horizontal][vertical]** blades.
 3. Discharge Nozzle: Discharge at **[25 to 65 degrees (0.44 to 1.13 radians)][50 to 90 degrees (0.87 to 1.57 radians)]** from horizontal.
- E. Accessories:
 1. Oil Booster Pump: **[30-gph (108-L/h)][70-gph (252-L/h)]** capacity; motor and two-stage fuel unit with pressure-regulating valve and strainer.
 2. Oil safety valve.
 3. Outdoor Combustion-Air Adapter: Sealed to housing and fitted with quick access cover or door and fitting for terminating outdoor-air duct.
- F. Heat Exchanger: Minimum **0.09-inch (2.2-mm)** steel.

- G. Burners: Flame-retention, pressure-atomizing, forced-draft, gun type; with integral fuel pump and electronic spark ignition and flame safety.
 - 1. Safety Device: Oil-pressure switch.
- H. Propeller Unit Fan:
 - 1. Aluminum blades dynamically balanced and resiliently mounted.
 - 2. Steel fan-blade guard.
- I. Centrifugal Unit Fan:
 - 1. Steel, centrifugal fan dynamically balanced and resiliently mounted.
 - 2. Belt driven with adjustable-pitch motor sheave.
- J. Motors:
 - 1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2. Enclosure Materials: Rolled steel.
 - 3. Motor Bearings: **<Insert requirements>**.
 - 4. Unusual Service Conditions:
 - a. Ambient Temperature: **<Insert deg C>**.
 - b. Altitude: **<Insert feet (m)>** above sea level.
 - c. High humidity.
 - d. **<Insert conditions>**.
 - 5. Efficiency: Premium efficient.
 - 6. NEMA Design: **<Insert designation>**.
 - 7. Service Factor: **<Insert value>**.
- K. Controls: Factory piped and prewired to electrical junction box mounted on unit, including the following:
 - 1. Control Transformer: Integrally mounted, 120- to 24-V ac.
 - 2. Cad-cell safety system.
 - 3. Manual reset safety.
 - 4. Automatic Fan Thermal Switch: Fan operates with heat-exchanger temperature more than **135 deg F (58 deg C)**.
 - 5. Thermostat: **[Devices and wiring are specified in Section 230923.27 "Temperature Instruments."]**
 - a. Mounting: **[Wall][Unit]**.
 - b. **[Single][Two]** stage.
 - c. Fan on-off-automatic switch.
 - d. 24-V ac.
 - e. **50 to 90 deg F (10 to 32 deg C)** operating range.
- L. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install and connect oil-fired unit heaters and associated fuel and vent piping according to **[NFPA 31][CSA B139]**, applicable local codes and regulations, and manufacturer's written instructions.

3.2 EQUIPMENT MOUNTING

- A. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
 - 1. Threaded Rods, Spring Hangers, and Building Attachments: Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 230548 "Vibration and Seismic Controls for HVAC."
 - 2. Threaded Rods, Spring Hangers, Building Attachments, and Seismic Restraints: Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." and Section 230548 "Vibration and Seismic Controls for HVAC"
 - 3. Anchor the unit to resist code-required horizontal acceleration.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to oil-fired unit heater, allow space for service and maintenance.
- C. Fuel Oil Piping: Comply with Section 231113 "Facility Fuel-Oil Piping." Connect to fuel oil supply and return piping with shutoff valve and union at each connection.
- D. Vent Connections: Comply with Section 235123 "Gas Vents."
- E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 2. Verify bearing lubrication.
 - 3. Verify proper motor rotation.
 - 4. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.



- b. Test results that comply with requirements.
- c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Oil-fired unit heater will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.6 DEMONSTRATION

A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain oil-fired unit heaters.

END OF SECTION 23 55 33 00



SECTION 23 55 33 00A - GAS-FIRED UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Gas-fired unit heaters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of gas-fired unit heater.

1. Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: For gas-fired unit heaters[; **signed and sealed by a qualified professional engineer**]. Include plans, elevations, sections, and attachment details.

1. Prepare by or under the supervision of a qualified professional engineer detailing fabrication and assembly of gas-fired unit heaters, as well as procedures and diagrams.
2. Design Calculations: Calculate requirements for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Include diagrams for power[, **signal, and control**] wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which equipment will be attached.
2. Items penetrating roof and the following:
 - a. Vent and gas piping rough-ins and connections.
 - b. **<Insert item>**.

B. Seismic Qualification Certificates: For gas-fired unit heaters, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

- D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gas-fired unit heaters to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Fan Belts: **[One]<Insert number>** for each belt-driven fan size.

1.6 QUALITY ASSURANCE

- A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of gas-fired unit heater that fails in materials or workmanship within specified warranty period.

- 1. Warranty Period: **[Two][Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Gas-fired unit heaters shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.

- 1. Seismic Fabrication Requirements: Fabricate and reinforce suspension attachments of gas-fired unit heaters, accessories mountings, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when gas-fired unit heater is anchored to building structure.
 - 2. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- C. Capacities and Characteristics:

1. Gas Input: **<Insert Btu/h (kW)>**.
2. Gas Output: **<Insert Btu/h (kW)>**.
3. Annual Gas Utilization Efficiency: **[80]<Insert number>** percent.
4. Minimum Airflow: **<Insert cfm (L/s)>**.
5. External Static Pressure: **<Insert inches wg (kPa)>**.
6. Motor Enclosure: Totally enclosed, fan cooled.
7. Electrical Characteristics:
 - a. Motor Size: **<Insert horsepower>**.
 - b. Motor Speed: **<Insert number>** rpm.
 - c. Volts: **[120][208][230]<Insert value>**.
 - d. Phase: **[Single][Poly]**.
 - e. Hertz: 60.
 - f. Full-Load Amperes: **<Insert value>**.
 - g. Minimum Circuit Ampacity: **<Insert value>**.
 - h. Maximum Overcurrent Protection: **<Insert amperage>**.

2.2 GAS-FIRED UNIT HEATERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Lennox]**
 2. **[Modine Manufacturing Company]**
 3. **[REZNOR, a brand of Nortek Global HVAC]**
 4. **[Sterling HVAC Products; a Mestek company]**
 5. **[Trane]**
 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Lennox]**
 2. **[Modine Manufacturing Company]**
 3. **[REZNOR, a brand of Nortek Global HVAC]**
 4. **[Sterling HVAC Products; a Mestek company]**
 5. **[Trane]**
 6. **<Insert manufacturer's name>**
- C. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.
- D. Gas Type: Design burner for **[natural][propane]** gas having characteristics same as those of gas available at Project site.
- E. Type of Venting: **[Gravity][Powered][Indoor, separated combustion, power]** vented.
- F. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.
 1. External Casings and Cabinets: **[Baked enamel][Powder coating]** over corrosion-resistant-treated surface.
 2. Discharge Louvers: Independently adjustable, **[horizontal][vertical]** blades.
 3. Discharge Nozzle: Discharge at **[25 to 65 degrees (0.44 to 1.13 radians)][50 to 90 degrees (0.87 to 1.57 radians)]** from horizontal.

- G. Accessories:
1. Four-point suspension kit.
 2. Power Venter: Centrifugal aluminized-steel fan, with stainless steel shaft; 120-V ac motor.
 3. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.
- H. Heat Exchanger: **[Aluminized][Stainless]** steel.
- I. Burner Material: **[Aluminized steel with stainless steel inserts][Stainless steel]**.
- J. Propeller Unit Fan:
1. **[Formed-steel][Aluminum]** propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
 2. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
- K. Centrifugal Unit Fan:
1. Steel, centrifugal fan dynamically balanced and resiliently mounted.
 2. Belt-Driven Drive Assembly:
 - a. Resiliently mounted to housing, with the following features:
 - 1) Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 2) Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 3) Pulleys: Cast-iron, adjustable-pitch motor pulley.
- L. Motors:
1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 2. Enclosure Materials: Rolled steel.
 3. Motor Bearings: **<Insert requirements>**.
 4. Unusual Service Conditions:
 - a. Ambient Temperature: **<Insert deg C>**.
 - b. Altitude: **<Insert feet (m)>** above sea level.
 - c. High humidity.
 - d. **<Insert conditions>**.
 5. Efficiency: Premium efficient.
 6. NEMA Design: **<Insert designation>**.
 7. Service Factor: **<Insert value>**.
- M. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
1. Gas Control Valve: **[Single stage][Two stage][Modulating]**.
 2. Ignition: **[Standing pilot][Electronically controlled electric spark with flame sensor]**.
 3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
 4. Vent Flow Verification: **[Flame rollout switch][Differential pressure switch to verify open]**

- vent].
 - 5. Control transformer.
 - 6. High Limit: Thermal switch or fuse to stop burner.
 - 7. Thermostat: **[Devices and wiring are specified in Section 230923.27 "Temperature Instruments."]**
 - a. Mounting: **[Wall][Unit]**.
 - b. **[Single][Two]** stage.
 - c. Fan on-off-automatic switch.
 - d. 24-V ac.
 - e. **50 to 90 deg F (10 to 32 deg C)** operating range.
- N. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install and connect gas-fired unit heaters and associated gas and vent features and systems according to **[NFPA 54][CSA B149.1]**, applicable local codes and regulations, and manufacturer's written instructions.

3.2 EQUIPMENT MOUNTING

- A. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
- B. Substrate-Mounted Units: Provide supports connected to substrate. Secure units to supports.
 - 1. Spring hangers **[and seismic restraints]** are specified in **[Section 230529 "Hangers and Supports for HVAC Piping and Equipment."][Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 230548 "Vibration and Seismic Controls for HVAC."]**
 - 2. Threaded Rods, Spring Hangers, and Building Attachments: Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Threaded Rods, Spring Hangers, Building Attachments, and Seismic Restraints: Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." and Section 230548 "Vibration and Seismic Controls for HVAC."
 - 4. Anchor the unit to resist code-required horizontal acceleration.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to gas-fired unit heater, allow space for service and maintenance.
- C. Gas Piping: Comply with **[Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping."]** Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.

- D. Vent Connections: Comply with Section 235123 "Gas Vents."
- E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 2. Verify bearing lubrication.
 - 3. Verify proper motor rotation.
 - 4. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- C. Gas-fired unit heater will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.6 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain gas-fired unit heaters.

END OF SECTION 23 55 33 00A



SECTION 23 57 00 00 - HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Shell-and-tube heat exchangers.
 2. Gasketed-plate heat exchangers.
 3. Brazed-plate heat exchangers.

1.2 DEFINITIONS

- A. TEMA: Tubular Exchanger Manufacturers Association.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
 2. Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment.
- C. Delegated Design Submittal: Details and design calculations for seismic restraints for heat exchangers.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Equipment room plan or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Seismic Qualification Data: Certificates, for heat exchanger, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Heat Exchanger: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of heat exchanger anchorage devices on which certification is based and their installation requirements.
- C. Product Certificates: For each type of shell-and-tube heat exchanger. Documentation that shell-and-

tube heat exchangers comply with "TEMA Standards."

- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranty: For manufacturer's warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of heat exchangers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

- a. Structural failures, including heat exchanger, storage tank, and supports.
- b. Faulty operation of controls.
- c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Shell-and-Tube Heat Exchangers:

- 1) Tube Coil: **[One]<Insert number> year(s).**
- 2) Other Components: **[One]<Insert number> year(s).**

b. Plate Heat Exchangers:

- 1) Brazed-Plate Type: **[One]<Insert number> year(s).**
- 2) Gasketed-Plate Type; **[One]<Insert number> year(s).**

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic restraints for heat exchangers.
- B. Seismic Performance: Heat exchangers shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"
 - 2. Component Importance Factor is **[1.5][1.0]**.

3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>.**

2.2 SHELL-AND-TUBE HEAT EXCHANGERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Alfa Laval Inc.]**
2. **[API Heat Transfer Inc.]**
3. **[Armstrong Fluid Technology]**
4. **[Bell & Gossett; a Xylem brand]**
5. **[Delta T Heat Exchangers]**
6. **[Flo Fab Inc]**
7. **[Kelvion, Inc.]**
8. **[Maxi-Therm]**
9. **[Spirax Sarco Limited]**
10. **[Taco Comfort Solutions]**
11. **[Thermo Dynamics Ltd.]**
12. **[Thrush Co. Inc.]**
13. **[Wessels Company]**
14. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Alfa Laval Inc.]**
2. **[API Heat Transfer Inc.]**
3. **[Armstrong Fluid Technology]**
4. **[Bell & Gossett; a Xylem brand]**
5. **[Delta T Heat Exchangers]**
6. **[Flo Fab Inc]**
7. **[Kelvion, Inc.]**
8. **[Maxi-Therm]**
9. **[Spirax Sarco Limited]**
10. **[Taco Comfort Solutions]**
11. **[Thermo Dynamics Ltd.]**
12. **[Thrush Co. Inc.]**
13. **[Wessels Company]**
14. **<Insert manufacturer's name>**

- C. Description: Packaged assembly of tank, heat-exchanger coils, and specialties.

- D. Construction:

1. Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
2. Fabricate and label shell-and-tube heat exchangers to comply with "TEMA Standards."

- E. Configuration: **[U-tube with removable][Straight tube with removable][Straight tube with fixed]** bundle.

- F. Shell Materials: **[Steel][Stainless steel]**.

- G. Head:
1. Materials: **[Cast iron][Cast stainless steel][Fabricated steel][Fabricated steel with removable cover][Fabricated stainless steel][Fabricated stainless steel with removable cover]**.
 2. Flanged and bolted to shell.
- H. Tube: **[Seamless copper][Steel][Cupronickel][Stainless steel]** tubes.
1. Tube diameter is determined by manufacturer based on service.
- I. Tubesheet Materials: **[Steel][Stainless steel]**.
- J. Baffles: **[Steel][Stainless steel]**.
- K. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tapings to shell before testing and labeling.
1. **NPS 2 (DN 50)** and Smaller: Threaded ends in accordance with ASME B1.20.1.
 2. **NPS 2-1/2 (DN 65)** and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
- L. Support Saddles:
1. Fabricated of material similar to shell.
 2. Fabricate foot mount with provision for anchoring to support.
- M. Capacities and Characteristics:
1. General:
 - a. Shell Diameter: **<Insert inches (mm)>**.
 - b. Heat-Exchanger Length: **<Insert inches (mm)>**.
 - c. Heat-Exchanger Surface Area: **<Insert sq. ft. (sq. m)>**.
 - d. Number of Passes: **<Insert number>**.
 - e. Heat Exchanged: **<Insert Btu/h (kW)>**.
 - f. Operating Weight: **<Insert lb (kg)>**.
 2. Shell Side:
 - a. Fluid: **[Water][Steam]<Insert type>**.
 - b. Working Pressure: **<Insert psig (kPa)>**.
 - c. Supply Pressure: **<Insert psig (kPa)>**.
 - d. Steam-Flow Rate: **<Insert lb/h (kg/h)>**.
 - e. Water-Flow Rate: **<Insert gpm (L/s)>**.
 - f. Pressure Drop: **<Insert psig (kPa)>**.
 - g. Inlet Temperature: **<Insert deg F (deg C)>**.
 - h. Outlet Temperature: **<Insert deg F (deg C)>**.
 - i. Fouling Factor: **<Insert value>**.
 - j. Inlet Size: **<Insert NPS (DN)>**.
 - k. Outlet Size: **<Insert NPS (DN)>**.
 3. Tube Side:
 - a. Fluid: **[Water][Steam]<Insert type>**.

- b. Working Pressure: **<Insert psig (kPa)>**.
- c. Supply Pressure: **<Insert psig (kPa)>**.
- d. Steam-Flow Rate: **<Insert lb/h (kg/h)>**.
- e. Water-Flow Rate: **<Insert gpm (L/s)>**.
- f. Pressure Drop: **<Insert psig (kPa)>**.
- g. Inlet Temperature: **<Insert deg F (deg C)>**.
- h. Outlet Temperature: **<Insert deg F (deg C)>**.
- i. Fouling Factor: **<Insert value>**.
- j. Inlet Size: **<Insert NPS (DN)>**.
- k. Outlet Size: **<Insert NPS (DN)>**.

2.3 GASKETED-PLATE HEAT EXCHANGERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1. **[Alfa Laval Inc.]**
- 2. **[API Heat Transfer Inc.]**
- 3. **[Armstrong Fluid Technology]**
- 4. **[Bell & Gossett; a Xylem brand]**
- 5. **[Delta T Heat Exchangers]**
- 6. **[Flo Fab Inc]**
- 7. **[Kelvion, Inc.]**
- 8. **[Polaris Heat Exchangers]**
- 9. **[SEC Heat Exchangers]**
- 10. **[Taco Comfort Solutions]**
- 11. **[Tranter, Inc]**
- 12. **[Weil-McLain]**
- 13. **[Wessels Company]**
- 14. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1. **[Alfa Laval Inc.]**
- 2. **[API Heat Transfer Inc.]**
- 3. **[Armstrong Fluid Technology]**
- 4. **[Bell & Gossett; a Xylem brand]**
- 5. **[Delta T Heat Exchangers]**
- 6. **[Flo Fab Inc]**
- 7. **[Kelvion, Inc.]**
- 8. **[Polaris Heat Exchangers]**
- 9. **[SEC Heat Exchangers]**
- 10. **[Taco Comfort Solutions]**
- 11. **[Tranter, Inc]**
- 12. **[Weil-McLain]**
- 13. **[Wessels Company]**
- 14. **<Insert manufacturer's name>**

- C. Configuration: Freestanding assembly, consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets. Floor-mounted heat exchangers must have integral legs with mounting feet.

- D. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel

Code, Section VIII, "Pressure Vessels," Division 1.

- E. Frame:
1. Capacity to accommodate [20]<Insert number> percent additional plates.
 2. Painted carbon steel with provisions for anchoring to support.
- F. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.
1. Fabricate attachment of heat-exchanger support bars and guide bars with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger support bars and guide bars are anchored to building structure.
- G. End-Plate Material: Painted carbon steel.
- H. Tie Rods and Nuts: Steel or stainless steel.
- I. Plate Material: [0.024 inch (0.6 mm)][0.031 inch (0.8 mm)][0.039 inch (1 mm)]<Insert thickness> thick before stamping; [Type 304][Type 304L][Type 316][Type 316L] stainless steel.
- J. Gasket Materials: [Glued][Glue free][Nitrile rubber][EPDM rubber]<Insert material>.
1. Glue: Chlorine free.
- K. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tapings to shell before testing and labeling.
1. **NPS 2 (DN 50)** and Smaller: Threaded ends in accordance with ASME B1.20.1.
 2. **NPS 2-1/2 (DN 65)** and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
- L. Enclose plates in solid [aluminum][stainless steel] removable shroud.
- M. Capacities and Characteristics:
1. General:
 - a. Heat-Exchanger Surface Area: <Insert sq. ft. (sq. m)>.
 - b. Number of Plates: <Insert number>.
 - c. Number of Passes: [One]<Insert number>.
 - d. Heat Exchanged: <Insert Btu/h (kW)>.
 - e. Operating Weight: <Insert lb (kg)>.
 2. Hot Side:
 - a. Fluid: [Water][Steam]<Insert type>.
 - b. Working Pressure: <Insert psig (kPa)>.
 - c. Supply Pressure: <Insert psig (kPa)>.
 - d. Steam-Flow Rate: <Insert lb/h (kg/h)>.
 - e. Water-Flow Rate: <Insert gpm (L/s)>.
 - f. Pressure Drop: <Insert psig (kPa)>.
 - g. Inlet Temperature: <Insert deg F (deg C)>.
 - h. Outlet Temperature: <Insert deg F (deg C)>.
 - i. Fouling Factor: <Insert value>.

- j. Inlet Size: **<Insert NPS (DN)>**.
 - k. Outlet Size: **<Insert NPS (DN)>**.
3. Cold Side:
- a. Fluid: **[Water][Steam]<Insert type>**.
 - b. Working Pressure: **<Insert psig (kPa)>**.
 - c. Supply Pressure: **<Insert psig (kPa)>**.
 - d. Steam-Flow Rate: **<Insert lb/h (kg/h)>**.
 - e. Water-Flow Rate: **<Insert gpm (L/s)>**.
 - f. Pressure Drop: **<Insert psig (kPa)>**.
 - g. Inlet Temperature: **<Insert deg F (deg C)>**.
 - h. Outlet Temperature: **<Insert deg F (deg C)>**.
 - i. Fouling Factor: **<Insert value>**.
 - j. Inlet Size: **<Insert NPS (DN)>**.
 - k. Outlet Size: **<Insert NPS (DN)>**.

2.4 BRAZED-PLATE HEAT EXCHANGERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1. **[Alfa Laval Inc.]**
 - 2. **[API Heat Transfer Inc.]**
 - 3. **[Armstrong Fluid Technology]**
 - 4. **[Bell & Gossett; a Xylem brand]**
 - 5. **[Delta T Heat Exchangers]**
 - 6. **[Flo Fab Inc]**
 - 7. **[Kelvion, Inc.]**
 - 8. **[Polaris Heat Exchangers]**
 - 9. **[Tranter, Inc]**
 - 10. **[Weil-McLain]**
 - 11. **[Wessels Company]**
 - 12. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1. **[Alfa Laval Inc.]**
 - 2. **[API Heat Transfer Inc.]**
 - 3. **[Armstrong Fluid Technology]**
 - 4. **[Bell & Gossett; a Xylem brand]**
 - 5. **[Delta T Heat Exchangers]**
 - 6. **[Flo Fab Inc]**
 - 7. **[Kelvion, Inc.]**
 - 8. **[Polaris Heat Exchangers]**
 - 9. **[Tranter, Inc]**
 - 10. **[Weil-McLain]**
 - 11. **[Wessels Company]**
 - 12. **<Insert manufacturer's name>**
- C. Configuration: Brazed assembly, consisting of embossed or pressed stainless steel plates brazed together and two end plates, one with threaded nozzles and one with pattern-embossed plates. Floor-mounted heat exchangers must have factory-furnished integral legs with mounting feet.

- D. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
- E. End-Plate Material: Type 316 stainless steel.
- F. Threaded Nozzles: Type 316 stainless steel.
- G. Plate Material: Type 316 stainless steel.
- H. Brazing Material: **[Copper][or][nickel]**.
- I. Capacities and Characteristics:
 - 1. General:
 - a. Heat-Exchanger Surface Area: **<Insert sq. ft. (sq. m)>**.
 - b. Heat Exchanged: **<Insert Btu/h (kW)>**.
 - c. Operating Weight: **<Insert lb (kg)>**.
 - 2. Hot Side:
 - a. Fluid: **[Water][Steam]<Insert type>**.
 - b. Working Pressure: **<Insert psig (kPa)>**.
 - c. Supply Pressure: **<Insert psig (kPa)>**.
 - d. Steam-Flow Rate: **<Insert lb/h (kg/h)>**.
 - e. Water-Flow Rate: **<Insert gpm (L/s)>**.
 - f. Pressure Drop: **<Insert psig (kPa)>**.
 - g. Inlet Temperature: **<Insert deg F (deg C)>**.
 - h. Outlet Temperature: **<Insert deg F (deg C)>**.
 - i. Fouling Factor: **<Insert value>**.
 - j. Inlet Size: **<Insert NPS (DN)>**.
 - k. Outlet Size: **<Insert NPS (DN)>**.
 - 3. Cold Side:
 - a. Fluid: **[Water][Steam]<Insert type>**.
 - b. Working Pressure: **<Insert psig (kPa)>**.
 - c. Supply Pressure: **<Insert psig (kPa)>**.
 - d. Steam-Flow Rate: **<Insert lb/h (kg/h)>**.
 - e. Water-Flow Rate: **<Insert gpm (L/s)>**.
 - f. Pressure Drop: **<Insert psig (kPa)>**.
 - g. Inlet Temperature: **<Insert deg F (deg C)>**.
 - h. Outlet Temperature: **<Insert deg F (deg C)>**.
 - i. Fouling Factor: **<Insert value>**.
 - j. Inlet Size: **<Insert NPS (DN)>**.
 - k. Outlet Size: **<Insert NPS (DN)>**.

2.5 ACCESSORIES

- A. Hangers and Supports:
 - 1. Custom-built steel supports and saddles for mounting on **[floor][wall][structural steel]**.

- a. Minimum Number of Saddles: **<Insert number>**.
2. Supports and saddles to ensure both horizontal and vertical support of heat exchanger. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Shroud: **[Steel][Stainless steel][Aluminum]** sheet.
- C. Miscellaneous Components for High-Temperature, Hot-Water Unit: Control valve, valves, thermometers, and piping. **[Include components fitted for][pneumatic control][electric control][electronic control]**.
- D. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gauge, thermometers, and piping. **[Include components fitted for][pneumatic control][electric control][electronic control]**.
- E. Pressure-Relief Valves: **[Cast iron][Steel][Bronze][Brass]**, **<Insert NPS (DN)>**, ASME rated and stamped.
 1. Pressure-relief valve setting: **<Insert psig (kPa)>**.

2.6 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect heat exchangers in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1. Affix ASME International label.
- B. Hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.
- C. Heat exchangers will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.
- B. Examine roughing-in for heat-exchanger piping to verify actual locations of piping connections before equipment installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HEAT EXCHANGER, GENERAL

- A. Equipment Mounting:
 1. Install floor-mounted heat exchangers on cast-in-place concrete equipment bases. Install all heat exchangers level and plumb in accordance with manufacturer's recommendations. Install floor-mounted and wall-hung steam heat exchangers at sufficient height, using sufficient length supports, to achieve required steam and condensate pipe pitch. Comply with requirements for

- equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 INSTALLATION OF SHELL-AND-TUBE HEAT EXCHANGER

- A. Install heat exchangers on saddle supports.
- B. Heat-Exchanger Supports: Mount heat exchanger on steel saddles and supports specifically designed for each heat exchanger.
- C. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger saddles are anchored to building structure.

3.4 INSTALLATION OF GASKETED-PLATE HEAT EXCHANGER

- A. Install wall-mounted gasketed-plate heat exchanger on custom-designed wall supports anchored to structure as indicated on Drawings.
- B. Install floor-mounted gasketed-plate heat exchangers on cast-in-place concrete equipment base, and fasten legs to base.
- C. Install metal shroud over installed gasketed-plate heat exchanger in accordance with manufacturer's written instructions.

3.5 INSTALLATION OF BRAZED-PLATE HEAT EXCHANGER

- A. Install wall-mounted brazed-plate heat exchanger on custom-designed wall supports anchored to structure as indicated on Drawings.
- B. Install floor-mounted brazed-plate heat exchangers on cast-in-place concrete equipment base and fasten legs to base.

3.6 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
- C. Maintain manufacturer's recommended clearances for tube removal, service, and maintenance.
- D. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.
- E. Install shutoff valves at heat-exchanger inlet and outlet connections.
- F. Install pressure-relief valves on heat-exchanger shells where a connection has been provided on shell.

When no shell pressure-relief valve connection has been provided, install pressure-relief valve on shell outlet piping before any isolation valves.

- G. Install pressure-relief valves on heat-exchanger tube outlet piping before any isolation valves.
- H. Pipe pressure-relief valves, full size of valve connection, to floor drain.
- I. Install vacuum breaker at heat-exchanger steam inlet connection.
- J. Install hose end valve to drain shell.
- K. Install thermometer on each heat-exchanger fluid[**inlet and**] outlet piping. Comply with requirements for thermometers specified in Section 230500 "Common Work Results for HVAC."
- L. Install pressure gauges on each heat-exchanger fluid [**inlet and**] outlet piping[**and steam inlet piping**]. Comply with requirements for pressure gauges specified in Section 230500 "Common Work Results for HVAC."

3.7 CLEANING

- A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.
- B. Isolate heat exchangers from piping before flushing piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blind flanges in flanged joints to isolate equipment.
- C. Flush heat-exchanger piping systems with clean water; then remove and clean or replace strainer screens before reopening flow to heat exchangers.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency, Owner: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency, Contractor: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections[**with the assistance of a factory-authorized service representative**]:
- E. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- F. Heat exchanger will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain heat exchangers.

END OF SECTION 23 57 00 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 57 13 00	23 57 00 00	Heat Exchangers for HVAC
23 57 16 00	23 57 00 00	Heat Exchangers for HVAC
23 57 19 00	23 57 00 00	Heat Exchangers for HVAC
23 57 19 13	23 57 00 00	Heat Exchangers for HVAC
23 57 19 19	23 57 00 00	Heat Exchangers for HVAC
23 57 19 23	23 57 00 00	Heat Exchangers for HVAC
23 61 16 00	23 64 16 00	Centrifugal Water Chillers



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 62 00 00 - PACKAGED COMPRESSOR AND CONDENSER UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Compressor and condenser units, air cooled, 1 to 5 tons (3.5 to 17.6 kW).
2. Compressor and condenser units, air cooled, 6 to 120 tons (21 to 422 kW).

1.2 ACTION SUBMITTALS

A. Product Data: For each compressor and condenser unit.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.

B. Sustainable Design Submittals:

1. Product Data: For energy performance.
2. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
3. Product Data: For refrigerants, indicating compliance with refrigerant management practices.

C. Shop Drawings: For compressor and condenser units.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For compressor and condenser units indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by qualified professional engineer responsible for their preparation.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Design Calculations: Calculate requirements for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.
3. Calculate requirements for selecting vibration isolators [**and seismic restraints**][**and wind restraints**] and for designing vibration isolation bases.
4. Indicate compliance with "Performance Requirements" Article.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates for compressor and condenser units, accessories, and

components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- C. Startup service reports.
- D. Field quality-control reports.
- E. Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For compressor and condenser units to include in emergency, operation, and maintenance manuals.

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-In-Place Concrete."
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
- C. Coordinate installation of steel dunnage and metal work platforms. These items are specified in Section 051200 "Structural Steel Framing," and Section 055000 "Metal Fabrications."
- D. Coordinate location of piping and electrical rough-ins.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of compressor and condenser units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
 - a. Compressor failure.
 - b. Condenser coil leak.
2. Warranty Period: **[Five][10]<Insert number>** years from date of Substantial Completion.
3. Warranty Period (Compressor Only): **[Five][Seven][10]<Insert number>** years from date of Substantial Completion.
4. Warranty Period (Components Other Than Compressor): **[Five][10]<Insert number>** years from date of Substantial Completion.
5. Warranty Period (Condenser Coil Only): **[Five]<Insert number>** years from date of Substantial Completion.



PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design **[vibration isolation][seismic restraints][and][wind restraints]**.
- B. Seismic Performance: Compressor and condenser units are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **and the unit will be fully operational after the seismic event**."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- C. Wind-Restraint Performance:
 - 1. See **[Section 230548 "Vibration and Seismic Controls for HVAC][Section 230548.13 "Vibration Controls for HVAC"]** for requirements.
- D. Fabricate and label refrigeration system in accordance with ASHRAE 15 and ASHRAE 34.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6, "Heating, Ventilating, and Air-Conditioning."
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 1 TO 5 TONS (3.5 TO 17.6 kW)

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Carrier Global Corporation]**
 - 2. **[Continental Products]**
 - 3. **[Heatcraft Refrigeration Products LLC]**
 - 4. **[Lennox]**
 - 5. **[Ruud Air Conditioning Division]**
 - 6. **[Trane]**
 - 7. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 - 8. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Carrier Global Corporation]**
 - 2. **[Continental Products]**
 - 3. **[Heatcraft Refrigeration Products LLC]**
 - 4. **[Lennox]**
 - 5. **[Ruud Air Conditioning Division]**



6. **[Trane]**
 7. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 8. **<Insert manufacturer's name>**
- C. Description: Factory assembled and tested; consisting of compressor, condenser coil, fan, motors, refrigerant reservoir, and operating controls.
- D. Compressor Type: Scroll, hermetically sealed, with rubber vibration isolators.
1. Motor: **[Single][Two][Variable]** speed, and includes thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 2. Two-Speed Compressor: Include manual-reset, high-pressure switch and automatic-reset, low-pressure switch.
 3. Variable-Speed Compressor: Include manual-reset, high-pressure switch and automatic-reset, low-pressure switch.
 4. Accumulator: Suction tube.
- E. Refrigerant: **[R-410A][or]<Insert type>**.
- F. Condenser Coil: Seamless copper-tube, **[aluminum][copper]**-fin coil; **[circuited for integral liquid subcooler,]**with removable drain pan and brass service valves with service ports.
- G. Condenser Fan: Direct-drive, metal propeller fan; with permanently lubricated, totally enclosed fan motor with thermal-overload protection[**and ball bearings**].
1. Fin Spacing: **[Eight][20][22]<Insert value>** per inch.
- H. Accessories:
1. Crankcase heater.
 2. Cycle Protector: Automatic-reset timer to prevent rapid compressor cycling.
 3. **[Electronic programmable thermostat][Low-voltage thermostat and subbase]** to control compressor and condenser unit and evaporator fan.
 4. Evaporator Freeze Thermostat: Temperature-actuated switch that stops unit when evaporator reaches freezing temperature.
 5. Filter-dryer.
 6. High-Pressure Switch: Automatic-reset switch cycles compressor off on high refrigerant pressure.
 7. Liquid-line solenoid.
 8. Low-Ambient Controller:
 - a. Cycles condenser fan to permit operation down to **[30 deg F (minus 1 deg C)][0 deg F (minus 18 deg C)][with time-delay relay to bypass low-pressure switch]**.
 - b. Controls condenser fan speed to permit operation down to **minus 20 deg F (minus 29 deg C)[with time-delay relay to bypass low-pressure switch]**.
 9. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure.
 10. Plastic mounting base.
 11. Precharged and preinsulated suction and liquid tubing.
 12. Sound Hood: Wraps around sound attenuation cover for compressor.
 13. Thermostatic expansion valve for installation at evaporator coil.
 14. Fixed orifice for installation at evaporator coil.
 15. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off.
 16. Reversing valve.
 17. **<Insert accessories>**.

- I. Unit Casing: Galvanized steel, finished with **[baked enamel][baked powder-coat]**; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Mount service valves, fittings, and gauge ports on exterior of casing.

- J. Capacities and Characteristics:

- 1. Compressor and Condenser Unit:

- a. Full-Load Cooling Capacity: **<Insert MBh (kW)>**.
 - b. Energy-Efficiency Ratio (EER): **<Insert value>**.
 - c. Seasonal Energy-Efficiency Ratio (SEER): **<Insert value>**.
 - d. Coefficient of Performance (COP): **<Insert value>**.
 - e. Compressor Suction Temperature: **<Insert deg F (deg C)>**.

- 2. Refrigerant Connections:

- a. Liquid Pipe Size: **<Insert NPS (DN)>**.
 - b. Suction Pipe Size: **<Insert NPS (DN)>**.
 - c. Connection Type: **[Braze][or][flared]**.

- 3. Compressor:

- a. Number of Compressors: **<Insert value>**.
 - b. Motor Speed: **<Insert value>**.
 - c. Rated-Load Amperes: **<Insert value> A**.
 - d. Locked-Rotor Amperes: **<Insert value> A**.
 - e. Power Input: **<Insert kilowatts>**.

- 4. Air-Cooled Condenser:

- a. Ambient-Air Temperature: **<Insert deg F (deg C)>**.
 - b. Airflow: **<Insert cfm (L/s)>**.
 - c. Number of Condenser Fans: **<Insert number>**.
 - d. Condenser Fan Motor Size: **<Insert horsepower>**.

- 5. Electrical Characteristics:

- a. Kilowatt Input: **<Insert value>**.
 - b. Volts: **[208]<Insert value> V**.
 - c. Phase: **[1]<Insert value>**.
 - d. Hertz: **[60]<Insert value> Hz**.
 - e. Maximum Circuit Ampacity: **<Insert value> A**.
 - f. Maximum Instantaneous Current Flow during Startup: **<Insert value>**.
 - g. Maximum Overcurrent Protection: **<Insert value> A**.

2.3 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 6 TO 120 TONS (21 TO 422 kW)

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1. **[Carrier Global Corporation]**
 - 2. **[Daikin Applied]**
 - 3. **[Dunham-Bush, Inc]**
 - 4. **[Engineered Air]**



5. [Lennox]
 6. [Trane]
 7. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 8. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Carrier Global Corporation]
 2. [Daikin Applied]
 3. [Dunham-Bush, Inc]
 4. [Engineered Air]
 5. [Lennox]
 6. [Trane]
 7. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 8. <Insert manufacturer's name>
- C. Description: Factory assembled and tested, air cooled; consisting of casing, compressors, condenser coils, condenser fans and motors, and unit controls.
- D. Compressor:
1. Scroll: Hermetic scroll compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.
 - a. Capacity Control: [On-off compressor cycling][Hot-gas bypass].
 2. Rotary Screw: Hermetic or semihermetic rotary-screw compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.
 - a. Capacity Control: [On-off compressor cycling][Modulating slide-valve assembly or port unloaders][Variable-frequency controller][Hot-gas bypass].
- E. Refrigerant: [R-407C][or][R-410A]<Insert type>.
- F. Condenser Coil: [Seamless copper-tube][or][aluminum microchannel-tube], aluminum-fin coil, including subcooling circuit and backseating liquid-line service access valve.
1. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.
 2. Provide factory-applied [baked epoxy][phenolic] anti-corrosion coating to assembled coil.
- G. Condenser Fans: Propeller-type vertical discharge; either directly or belt driven. Include the following:
1. Permanently lubricated, ball-bearing[totally enclosed, air-over] motors.
 2. Separate motor for each fan.
 3. Dynamically and statically balanced fan assemblies.
- H. Operating and safety controls include the following:
1. Manual-reset, high-pressure cutout switches.
 2. Automatic-reset, low-pressure cutout switches.
 3. Low-oil-pressure cutout switch.
 4. Compressor-winding thermostat cutout switch.

5. Three-leg, compressor-overload protection.
 6. Control transformer.
 7. Magnetic contactors for compressor and condenser fan motors.
 8. Timer to prevent excessive compressor cycling.
- I. Accessories:
1. **[Electronic programmable thermostat][Low-voltage thermostat and subbase]** to control compressor and condenser unit and its associated evaporator fan.
 2. Low-Ambient Controller:
 - a. Cycles condenser fan to permit operation down to **0 deg F (minus 18 deg C)[with time-delay relay to bypass low-pressure switch]**.
 - b. Controls condenser fan speed to permit operation down to **minus 20 deg F (minus 29 deg C)[with time-delay relay to bypass low-pressure switch]**.
 3. Gauge Panel: Package with refrigerant circuit suction and discharge gauges.
 4. Hot-gas bypass kit.
 5. Part-winding-start timing relay, circuit breakers, and contactors.
 6. Reversing valve.
 7. Non-fused disconnect switch, factory mounted and wired, for single external electrical power connection. See Section 262816 "Enclosed Switches and Circuit Breakers."
 8. Low-noise fans.
 9. 115 V ac convenience, ground-fault circuit interrupter receptacle in weatherproof enclosure.
 10. Vibration isolation **[resilient][spring]** mounts.
 11. Security grilles.
 12. **<Insert accessories>**.
- J. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include the following:
1. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
 - a. Corrosion Resistance: **[500][1000]<Insert value>**-hour salt spray test, in accordance with ASTM B117.
 2. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
 3. Gasketed control panel door.
 4. Condenser coil **[hail guard][grille]**.
- K. Capacities and Characteristics:
1. Compressor and Condenser Unit:
 - a. Full-Load Cooling Capacity: **<Insert MBh (kW)>**.
 - b. Energy-Efficiency Ratio (EER): **<Insert value>**.
 - c. Seasonal Energy-Efficiency Ratio (SEER): **<Insert value>**.
 - d. Coefficient of Performance (COP): **<Insert value>**.
 - e. Compressor Suction Temperature: **<Insert deg F (deg C)>**.
 - f. Capacity Steps: **<Insert number>**.
 2. Refrigerant Connections:
 - a. Liquid Pipe Size: **<Insert NPS (DN)>**.

- b. Suction Pipe Size: **<Insert NPS (DN)>**.
- 3. Compressors:
 - a. Number of Compressors: **<Insert number>**.
 - b. Rated-Load Amperes: **<Insert value> A**.
 - c. Locked-Rotor Amperes: **<Insert value> A**.
 - d. Power Input: **<Insert kilowatts>**.
- 4. Air-Cooled Condenser:
 - a. Ambient-Air Temperature: **<Insert deg F (deg C)>**.
 - b. Airflow: **<Insert cfm (L/s)>**.
 - c. Number of Condenser Fans: **<Insert number>**.
 - d. Condenser Fan Motor Size: **<Insert horsepower>**.
- 5. Electrical Characteristics:
 - a. Kilowatt Input: **<Insert value>**.
 - b. Volts: **<Insert value> V**.
 - c. Phase: **<Insert value>**.
 - d. Hertz: **<Insert value> Hz**.
 - e. Maximum Circuit Ampacity: **<Insert value> A**.
 - f. Maximum Instantaneous Current Flow during Startup: **<Insert value>**.
 - g. Maximum Overcurrent Protection: **<Insert value> A**.

2.4 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.5 SOURCE QUALITY CONTROL

- A. Performance Ratings: Certify capacity performance ratings of compressor and condenser units in accordance with **[AHRI 210/240][AHRI 340/360]**.
- B. Sound-Power Level Ratings: Factory test sound-power-level ratings in accordance with **[AHRI 270][AHRI 370]**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of compressor and condenser units.
- B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections

before equipment installation.

- C. Examine walls, floors, and roofs for suitable conditions where compressor and condenser units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install units level and plumb, firmly anchored in locations indicated.
- B. Install roof-mounting units on equipment supports specified in Section 077200 "Roof Accessories."
- C. Install roof-mounting units on **[steel dunnage][access platform]** specified in Section 051200 "Structural Steel Framing" or Section 055000 Metal Fabrications, or on equipment supports specified in Section 077200 "Roof Accessories."
- D. Equipment Mounting:
 - 1. Install compressor and condenser units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-In-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Maintain manufacturer's recommended clearances for service and maintenance.
- F. Loose Components: Install piping specialties, electrical components, devices, and accessories that are not factory mounted.

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.
- C. Connect precharged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.
- D. Connect refrigerant piping to air-cooled compressor and condenser units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Section 232300 "Refrigerant Piping."

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."



- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions and perform the following:
 - a. Inspect for physical damage to unit casing.
 - b. Verify that access doors move freely and are weathertight.
 - c. Clean units and inspect for construction debris.
 - d. Verify that all bolts and screws are tight.
 - e. Adjust vibration isolation and flexible connections.
 - f. Verify that controls are connected and operational.
- B. Start unit in accordance with manufacturer's written instructions and complete manufacturer's startup checklist.
- C. Measure and record airflow and air temperature rise over coils.
- D. Verify operation of condenser capacity control device.
- E. Verify that vibration isolation and flexible connections prevent vibration transmission to structure.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:

1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
 2. Leak Test: After installation, charge system with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor operation and unit operation, product capability, and compliance with requirements.
 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 5. Verify manufacturer's required airflow over coils.
- D. Verify that vibration isolation and flexible connections prevent vibration transmission to structure.
- E. Compressor and condenser units will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.8 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain compressor and condenser units.

END OF SECTION 23 62 00 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 62 13 00	23 62 00 00	Packaged Compressor and Condenser Units
23 62 13 00	23 64 13 16	Indirect-Fired Absorption Water Chillers
23 62 23 00	23 62 00 00	Packaged Compressor and Condenser Units



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 63 13 00 - AIR-COOLED REFRIGERANT CONDENSERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Packaged air-cooled refrigerant condensers.

1.2 ACTION SUBMITTALS

- A. Product Data: For each air-cooled refrigerant condenser.
1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
 2. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.
- B. Sustainable Design Submittals:
1. Product Data for EA Credit 4, "Enhanced Refrigerant Management": Indicating that products meet requirements for refrigerant management.
 2. Product Data for EA Credit "Enhanced Refrigerant Management": Indicating that products meet requirements for refrigerant management.
 3. Product data showing compliance with ASHRAE 90.1.
- C. Shop Drawings: For air-cooled refrigerant condensers.
1. Include plans, elevations, sections, and **[mounting][attachment]** details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
- D. Delegated Design Submittal: For air-cooled refrigerant condensers indicated, to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 2. Design Calculations: Calculate requirements for selecting vibration isolators **[and seismic restraints]** and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Seismic Qualification Data: For air-cooled refrigerant condensers, accessories, and components, from

manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-cooled refrigerant condensers to include in emergency, operation, and maintenance manuals.

1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete."
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
- C. Coordinate location of refrigerant piping and electrical rough-ins.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. Fabricate and label refrigeration system in accordance with ASHRAE 15 and ASHRAE 34.
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- D. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[**and seismic restraints**], including comprehensive engineering analysis, using performance requirements and design criteria indicated.
- E. Seismic Performance: Air-cooled refrigerant condensers are to withstand the effects of earthquake motions determined in accordance with [**ASCE/SEI 7**]**<Insert requirement>**.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Component Importance Factor: [**1.5**][**1.0**].
 3. **<Insert requirements for Component Amplification Factor and Component Response**

Modification Factor>.

F. Capacities and Characteristics:

1. Heat-Rejection Capacity: **<Insert MBh (kW)>.**
2. Condensing Temperature:
 - a. Saturated Discharge Temperature: **<Insert deg F (deg C)>.**
 - b. Saturated Suction Temperature: **<Insert deg F (deg C)>.**
 - c. Subcooling Temperature: **<Insert deg F (deg C)>.**
3. Ambient-Air Temperature: **<Insert deg F (deg C)>.**
4. Refrigerant Pipe Connections:
 - a. Number of Connections: **<Insert number>.**
 - b. Liquid Pipe Size: **<Insert NPS (DN)>.**
 - c. Suction Pipe Size: **<Insert NPS (DN)>.**
5. Coils:
 - a. Arrangement: **<Insert description>.**
 - b. Number of Rows: **<Insert number>.**
 - c. Fin Spacing: **[8 fins/inch (3.0 mm)][10 fins/inch (2.5 mm)][12 fins/inch (2.0 mm)][14 fins/inch (1.8 mm)][16 fins/inch (1.6 mm)]<Insert value>.**
 - d. Total Face Area: **<Insert sq. ft. (sq. m)>.**
6. Fans:
 - a. Number of Condenser Fans: **<Insert number>.**
 - b. Diameter: **<Insert inches (mm)>.**
 - c. **[Constant][Variable]-speed.**
 - d. RPM: **<Insert number>.**
 - e. Total Airflow: **<Insert cfm (L/s)>.**
 - f. Condenser Fan Motor Size: **<Insert number> hp.**
7. Electrical Characteristics:
 - a. Kilowatts: **<Insert number>.**
 - b. Volts: **<Insert number>.**
 - c. Phase: **<Insert number>.**
 - d. Hertz: **<Insert number>.**
 - e. Maximum Circuit Ampacity: **<Insert number> A.**
 - f. Maximum Instantaneous Current Flow during Startup: **<Insert number>.**
 - g. Maximum Overcurrent Protection: **<Insert number> A.**

2.2 PACKAGED AIR-COOLED REFRIGERANT CONDENSERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Carrier Global Corporation]**
2. **[Heatcraft Refrigeration Products LLC]**
3. **[Trane]**
4. **[USA Coil & Air]**

5. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Carrier Global Corporation]**
 2. **[Heatcraft Refrigeration Products LLC]**
 3. **[Trane]**
 4. **[USA Coil & Air]**
 5. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 6. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain air-cooled refrigerant condensers from single source from single manufacturer.
- D. Description: Factory assembled and tested; consisting of casing, condenser coils, condenser fans and motors, and unit controls.
- E. Refrigerant: **[R-134A][R-404A][R-407C][or][R-410A]<Insert type>**.
- F. Condenser Coil: Factory tested at **425 psig (2930 kPa)**.
1. Tube: **[1/2-inch- (13-mm-) diameter seamless copper.][3/8-inch- (10-mm-) diameter seamless copper.][5/8-inch- (16-mm-) diameter seamless copper.]**
 2. Coil Fin: **[Aluminum][Copper]**.
 3. Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Enclosure Type: **[Totally enclosed, air-over (TEAO)][Open, drip-proof (ODP)]**.
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough, so driven load will not require motor to operate in service factor range above 1.0.
 - c. Mount unit-mounted disconnect switches on **[exterior][interior]** of unit.
 - d. **<Insert unique motor characteristics>**.
 4. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for condensers requiring a corrosion-resistant coating.
 5. Coating, Coils: **[None][Corrosion resistant]**.
 6. Coating, Fans: **[None][Corrosion resistant]**.
 7. Coating, Casing: **[None][Corrosion resistant]**.
 8. Circuit: To match compressors **[with liquid subcooling coil]**.
- G. Condenser Fans and Drives:
1. Directly driven propeller fans with **[aluminum or galvanized-steel][galvanized-steel]** fan blades, for **[vertical][horizontal]** air discharge; manufactured with permanently lubricated ball-bearing motors with integral current- and thermal-overload protection.
 2. Forward-curved centrifugal fans for **[vertical][horizontal]** air discharge.
 - a. Fan on steel shaft with self-aligning ball bearings.
 - b. V-belt drive with minimum of two belts; variable-pitch drive pulley.
 - c. Motor mounted on adjustable slide base.
 3. Fan Motors:

- a. Weather-proof motors with rain shield and shaft slinger.
 - b. **[Totally enclosed air-over (TEAO)][Open-drip proof (ODP)].**
 - c. **[Constant][Variable]** speed.
- H. Operating and Safety Controls: Include condenser fan motor thermal and overload cutouts; **[115-V][24-V]** control transformer, if required; magnetic contactors for condenser fan motors and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.
 - 1. Fan Cycling Control: **[Head pressure switches][Head pressure sensors][Ambient thermostats]**.
- I. Casings: **[Galvanized-steel or zinc-coated-steel treated and finished with manufacturer's standard paint coating][Aluminum]<Insert material>**, designed for outdoor installation with weather protection for components and controls, and with the following:
 - 1. Removable panels for access to controls, condenser fans, motors, and drives.
 - 2. Coating: **[None][Corrosion resistant]**.
 - 3. **[Vinyl-coated][Plated]** steel fan guards.
 - 4. Lifting holes.
 - 5. Removable legs, **[20 inches (500 mm)][30 inches (760 mm)][36 inches (910 mm)][42 inches (1060 mm)]** high.

2.3 MATERIALS

- A. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
 - 1. Manufacturer's standard grade for casing.
 - 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.
- D. Aluminum: **ASTM B209 (ASTM B209M)**.
- E. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a **[500]<Insert time>**-hour salt-spray test in accordance with ASTM B117.
 - 1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
 - c. ASTM B3359 for cross hatch adhesion of 5B.
 - 2. Application: **[Immersion][Spray]**.
 - 3. Thickness: **[1 mil (0.025 mm)]<Insert value>**.
 - 4. Gloss: Minimum gloss of 60 on a 60 degree meter.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of air-cooled refrigerant condensers.
- B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where air-cooled condensers will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF PACKAGED AIR-COOLED REFRIGERANT CONDENSERS

- A. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.
- B. Equipment Mounting:
 - 1. Install air-cooled condenser refrigerant condensers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Maintain manufacturer's recommended clearances for service and maintenance.
- D. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Refrigerant Piping: Where indicated on Drawings, connect piping to unit with pressure-relief, service valve, filter-dryer, and moisture indicator on each refrigerant-circuit liquid line.
- D. Apply labels to refrigerant lines in accordance with Section 230553, "Identification for HVAC Piping and Equipment."

3.4 ELECTRICAL CONNECTIONS

- A. Install field power to each condenser unit electrical power connection.

- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert dimension> high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions and perform the following:
 - a. Inspect for physical damage to unit casing.
 - b. Verify that access doors move freely and are weathertight.
 - c. Clean units and inspect for construction debris.
 - d. Verify that all bolts and screws are tight.
 - e. Adjust vibration isolation and flexible connections.
 - f. Verify that controls are connected and operational.
 - 2. Lubricate bearings on fan motors.
 - 3. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
 - 4. Adjust fan belts to proper alignment and tension.
 - 5. Start unit in accordance with manufacturer's written instructions and complete manufacturer's startup checklist.
 - 6. Measure and record airflow and air-temperature rise over coils.
 - 7. Verify proper operation of capacity control device.
 - 8. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
 - 9. After startup and performance test, lubricate bearings.



3.7 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 - 1. Perform electrical test and visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Complete manufacturer's starting checklist.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. Verify proper airflow over coils.
- E. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
- F. Air-cooled refrigerant condensers will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.8 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain air-cooled refrigerant condensers.

END OF SECTION 23 63 13 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 63 13 00	23 62 00 00	Packaged Compressor and Condenser Units
23 63 13 00	23 81 26 00	Split-System Air-Conditioners



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 64 13 00 - DIRECT-FIRED ABSORPTION WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Direct-fired absorption water chillers.
 2. Heat-exchanger, brush-cleaning system.

1.2 DEFINITIONS

- A. BAS: Building automation system.
- B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- C. IPLV: Integrated part-load value. A single-number, part-load efficiency figure of merit calculated per the method defined by AHRI 560 and referenced to AHRI standard rating conditions.
- D. NPLV: Nonstandard part-load value. A single-number, part-load efficiency figure of merit calculated per the method defined by AHRI 560 and intended for operating conditions other than the AHRI standard rating conditions.

1.3 ACTION SUBMITTALS

- A. Product Data: For the following:
1. Direct-fired absorption water chillers.
 2. Heat-exchanger, brush-cleaning system.
- B. Product Data Submittals: For each product. Include rated capacities, operating characteristics, furnished specialties and accessories, and the following:
1. Performance at AHRI standard conditions and at conditions indicated.
 2. Performance at AHRI standard unloading conditions.
 3. Minimum evaporator flow rate.
 4. Absorbent capacity of chiller.
 5. Refrigerant capacity of chiller.
 6. Liquid capacity of evaporator and condenser.
 7. Liquid capacity of generator.
 8. Characteristics of safety relief devices.
 9. Minimum entering condenser-liquid temperature.
 10. Performance at varying capacities with constant design condenser-liquid temperature. Repeat performance at varying capacities for different condenser-liquid temperatures from design to minimum in **[5 deg F (3 deg C)]<Insert temperature>** increments.
 11. If equipped, liquid capacity of dedicated hot-water heater exchanger.
 12. Combustion-air flow.
 13. Exhaust gas airflow.

14. Exhaust gas minimum and maximum operating temperature.

C. Sustainable Design Submittals:

1. Product Data: For energy performance.

D. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Insulated Surface Diagrams: Indicating cold and hot surfaces requiring field-applied insulation with surface area tabulated for each.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for chillers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source quality-control reports.

D. Startup service reports.

E. Test and inspection startup reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Ship chillers factory charged with nitrogen.

B. Ship absorbent and refrigerant in chillers or in containers separate from chillers.



- C. Ship **[absorbent][and][refrigerant]** in containers separate from chillers.
- D. Package chiller for export shipping in totally enclosed **[bagging][crate][crate with bagging]**.

1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
- B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
 - 1. Extended warranties include, but are not limited to, the following:
 - a. Complete chiller.
 - b. **[Pumps and motors][Purge unit][Burner assembly]<Insert components>**.
 - c. **[Absorbent][Absorbent and refrigerant]** only.
 - d. Parts **[only][and labor]**.
 - e. Loss of absorbent and refrigerant for any reason.
 - 2. Warranty Period: **[One][Two][Three][Four][Five]<Insert number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain chillers from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. AHRI Rating: Rate chiller performance in accordance with requirements in AHRI 560.
- B. ASHRAE Compliance:
 - 1. ASHRAE 15 and ASHRAE 34 for safety code for mechanical refrigeration.
 - 2. ASHRAE/IES 90.1.
- C. ASME Compliance: Fabricate and label chiller pressure vessels to comply with applicable portions of ASME Boiler and Pressure Vessel Code.
- D. Comply with NFPA 70.
- E. UL Compliance:
 - 1. Comply with requirements of UL and UL Canada, and include label by qualified testing agency

showing compliance.

2. [UL 726, "Oil-Fired Boiler Assemblies."][UL 795, "Commercial-Industrial Gas Heating Equipment."][UL 726, "Oil-Fired Boiler Assemblies"; and UL 795, "Commercial-Industrial Gas Heating Equipment."]

F. Seismic Performance: Direct-fired absorption water chillers are to withstand the effects of earthquake motions determined in accordance with [ASCE/SEI 7]<Insert requirement>.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[and the unit will be fully operational after the seismic event]."

G. Condenser-Liquid Temperature Performance:

1. Startup Condenser-Liquid Temperature: Provide chiller capable of starting with entering condenser-liquid temperature of [60 deg F (16 deg C)]<Insert temperature> and providing stable operation until system temperature is elevated to manufacturer's recommended minimum operating entering condenser-liquid temperature.
2. Minimum Operating Condenser-Liquid Temperature: Provide chiller capable of continuous operation over entire capacity range indicated with entering condenser-liquid temperature of [70 deg F (21 deg C)]<Insert temperature>.
3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

H. Site Altitude: Provide chiller suitable for altitude at which it is installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

I. Performance Tolerance: Comply with the following in lieu of AHRI 560:

1. Allowable Capacity Tolerance: [Zero]<Insert number> percent.
2. Allowable IPLV/NPLV Performance Tolerance: [Zero]<Insert number> percent.

2.3 CAPACITIES AND CHARACTERISTICS

A. Capacity: <Insert tons (kW)>.

B. Full-Load Efficiency (COP): <Insert number>.

C. Part-Load Efficiency:

1. IPLV: <Insert number>.
2. NPLV: <Insert number>.

D. Evaporator:

1. Pressure Rating: [150 psig (1035 kPa)][300 psig (2070 kPa)]<Insert number>.
2. Number of Passes: [Two][Three][Four]<Insert number>.
3. Liquid Type: [Water]<Insert liquid type>.
4. Design Liquid Flow Rate: <Insert gpm (L/s)>.
5. Minimum Liquid Flow Rate: <Insert gpm (L/s)>.
6. Entering-Liquid Temperature: <Insert deg F (deg C)>.
7. Leaving-Liquid Temperature: <Insert deg F (deg C)>.
8. Liquid Pressure Drop: <Insert feet of head (kPa)>.
9. Liquid Velocity: <Insert fps (m/s)>.

10. Fouling Factor: [0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000045 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert value>.
- E. Absorber/Condenser:
1. Pressure Rating: [150 psig (1035 kPa)][300 psig (2070 kPa)]<Insert number>.
 2. Number of Passes: [One][Two][Three].
 3. Liquid Type: [Water]<Insert liquid type>.
 4. Design Liquid Flow Rate: <Insert gpm (L/s)>.
 5. Entering-Liquid Temperature: <Insert deg F (deg C)>.
 6. Leaving-Liquid Temperature: <Insert deg F (deg C)>.
 7. Liquid Pressure Drop: <Insert feet of head (kPa)>.
 8. Liquid Velocity: <Insert fps (m/s)>.
 9. Fouling Factor: [0.00025 sq. ft. x h x deg F/Btu (0.000045 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)][0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W)]<Insert value>.
- F. Dedicated Hot-Water Heat Exchanger:
1. Capacity: <Insert MBtu/h (kW)>.
 2. Pressure Rating: [150 psig (1035 kPa)][300 psig (2070 kPa)]<Insert number>.
 3. Number of Passes: [One][Two][Three][Four].
 4. Liquid Type: [Water]<Insert liquid type>.
 5. Design Liquid Flow Rate: <Insert gpm (L/s)>.
 6. Entering-Liquid Temperature: <Insert deg F (deg C)>.
 7. Leaving-Liquid Temperature: <Insert deg F (deg C)>.
 8. Liquid Pressure Drop: <Insert feet of head (kPa)>.
 9. Liquid Velocity: <Insert fps (m/s)>.
 10. Fouling Factor: [0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000045 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert value>.
- G. Burner Blower:
1. Motor Horsepower: <Insert number>.
 2. RPM: <Insert number>.
- H. Pump Horsepower:
1. Purge: <Insert number>.
 2. Refrigerant: <Insert number>.
 3. Solution: <Insert number>.
- I. Chiller Control Electrical Requirements:
1. Power Input: <Insert kilowatts>.
 2. Minimum Circuit Ampacity: <Insert value> A.
 3. Maximum Overcurrent Protection Device: <Insert value> A.
 4. Characteristics: [120]<Insert number> V ac, single phase, 60 Hz.
- J. Chiller Electrical Requirements:
1. Power Input: <Insert kilowatts>.
 2. Minimum Circuit Ampacity: <Insert value> A.
 3. Maximum Overcurrent Protection Device: <Insert value> A.

4. Characteristics: **[208][240][480]<Insert number>** V ac, three phase, 60 Hz.

K. Natural-Gas Heating Value: **<Insert Btu/cu. ft. (kJ/L)>**.

L. Natural Gas Input, Full-Fire: **<Insert cfm (mL/s)>**.

M. Fuel-Oil Heating Value: **<Insert Btu/gal. (MJ/L)>**.

N. Fuel-Oil Input, Full Fire: **<Insert gph (mL/s)>**.

O. Sound Power Level Rating: **[80][85]<Insert dBA>** sound power level when measured in accordance with AHRI 575. Provide factory-installed sound attenuation treatment if necessary to achieve performance indicated.

2.4 DIRECT-FIRED ABSORPTION WATER CHILLERS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Dunham-Bush, Inc]**
2. **[Trane / Thermax]**
3. **[Yazaki Energy Systems]**
4. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
5. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Dunham-Bush, Inc]**
2. **[Trane / Thermax]**
3. **[Yazaki Energy Systems]**
4. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
5. **<Insert manufacturer's name>**

C. Description: Factory-assembled and -tested, hermetic-design chiller, complete with absorber, evaporator, condenser, generator, solution heat exchanger, controls, absorbent solution pump with motor, refrigerant pump with motor, purge unit with motor, burner assembly, motor controllers, rupture disk, interconnecting unit piping and wiring, indicated accessories, and mounting frame.

1. Disassemble chiller into major assemblies, as required for installation, after factory testing and before packaging for shipment.

D. Absorbent and Refrigerant:

1. Absorbent: Lithium bromide solution with corrosion inhibitor.
2. Refrigerant: Deionized **[or][distilled]** water.
3. Performance Enhancer: Heat and mass transfer enhancer to improve performance.

E. Seismic Fabrication Requirements: Fabricate mounting base and attachment to chiller, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

F. Pumps:

1. Hermetically sealed, self-lubricating, and fitted with self-adjusting, spring-loaded, wear-compensating, tapered carbon bearings.
2. Pump motor assembly is to be designed to operate for not less than 50,000 hours between inspections.
3. Pump motors are to be cooled and bearings lubricated, by fluid being pumped.
4. Provide isolation valves at pump suction and discharge.
5. Provide separate pumps for absorbent solution and refrigerant.
 - a. Provide chiller manufacturer's recommended absorbent solution and refrigerant flow-control method, to comply with operating requirements indicated.
6. Purge System: Unit mounted and factory wired, equipped with controls and pump to automatically remove noncondensable vapors.
 - a. Purge Pump Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 1) Enclosure: **[Open dripproof][or][totally enclosed]**.

G. Heat-Exchanger Shells:

1. Configuration: Two shells; one shell consists of absorber/evaporator, low-stage generator/condenser; and one shell consists of high-stage generator. Where indicated, equip chiller with dedicated hot-water heat exchanger.
2. Construction: Fabricated from continuously welded carbon-steel sheet or plate, or from seamless pipe.
3. Design Pressure and Temperature Rating: Comply with applicable requirements in ASME Boiler and Pressure Vessel Code.
4. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between liquid in tubes and refrigerant in shell.
5. Intermediate Tube Sheets: Carbon-steel plates installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid tube contact resulting in abrasion and wear.
6. Generator/Condenser Shell Pressure Relief Device: Manufacturer's standard rupture disk complying with requirements in ASHRAE 15 and ASHRAE 34, and in applicable portions of ASME Boiler and Pressure Vessel Code.

H. Absorber:

1. Nozzle or Dispersion Trays: Designed to evenly distribute absorbent solution over tubes; constructed of brass, stainless steel, or another material that will not corrode.
2. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
 - b. Material: **[Copper][or][copper-nickel alloy]<Insert material>**.
 - c. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: **[Enhanced][or][smooth]**.
3. Water Boxes:

- a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from each end without disturbing refrigerant in shell.
 - b. **[Standard][Marine-type]** water box with piping connections.
 - 1) Water boxes **[and marine-type water-box covers]**with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - 3) Hinged marine-type water-box covers.
 - c. Standard water box without piping connections.
 - 1) Water boxes with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with **[3/4-inch (19-mm)][or][1-inch (25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.
4. Additional Corrosion Protection:
- a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with corrosion-resistant finish.
 - c. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with corrosion-resistant finish.
5. Absorber/Condenser Crossover Piping: Factory-furnished and -installed piping connecting liquid connection of absorber discharge to inlet connection of condenser.
- I. Evaporator:
1. Nozzle or Dispersion Trays: Designed to evenly distribute refrigerant over tubes; constructed of brass, stainless steel, or another material that will not corrode when exposed to absorbent.
 2. Refrigerant Holding Pan: Steel or stainless steel.
 3. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets, other tubes, and integrity of tube-tube sheet connections.
 - b. Material: **[Copper][or][copper-nickel alloy]<Insert material>**.
 - c. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: **[Enhanced][or][smooth]**.
4. Water Boxes:
- a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. **[Standard][Marine-type]** water box with piping connections.
 - 1) Water boxes **[and marine-type water-box covers]**with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - 3) Hinged marine-type water-box covers.

- c. Standard water box without piping connections.
 - 1) Water boxes with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - 3) Hinged marine water-box covers.
 - d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with **[3/4-inch (19-mm)][or][1-inch (25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.
- J. Condenser:
- 1. Refrigerant Holding Pan: Steel or stainless steel.
 - 2. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
 - b. Material: **[Copper][or][copper-nickel alloy]<Insert material>**.
 - c. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: **[Enhanced][or][smooth]**.
 - 3. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. **[Standard][Marine-type]** water box with piping connections.
 - 1) Water boxes **[and marine-type water-box covers]**with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - 3) Hinged marine-type water-box covers.
 - c. Standard water box without piping connections.
 - 1) Water boxes with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - 3) Hinged marine water-box covers.
 - d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with **[3/4-inch (19-mm)][or][1-inch (25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.
 - 4. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with corrosion-resistant finish.
 - c. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with corrosion-resistant finish.

K. First-Stage Generator:

1. Tubes:
 - a. **[Replaceable]**, straight, or U tubes expanded into tube sheets.
 - b. Material: **[Manufacturer's standard][Steel]<Insert material>**.
 - c. Minimum Wall Thickness: **[Manufacturer's choice]<Insert dimension>**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Manufacturer's choice; enhanced or smooth.
2. Water Boxes:
 - a. Carbon-steel construction; arranged to allow visual inspection and cleaning of tubes from each end without disturbing refrigerant in shell.
 - b. Standard water box.
 - c. Water boxes with lifting lugs or eyebolts.
 - d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with **[3/4-inch (19-mm)][or][1-inch (25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.

L. Second-Stage Generator:

1. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from each end without damage to tube sheets and other tubes.
 - b. Material: **[Copper][or][copper-nickel alloy]<Insert material>**.
 - c. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Manufacturer's standard.
2. Water Boxes:
 - a. Carbon-steel construction; arranged to allow visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard type.
 - c. Water boxes with lifting lugs or eyebolts.
 - d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with **[3/4-inch (19-mm)][or][1-inch (25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.

M. Dedicated Hot-Water Heat Exchanger:

1. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from each end without damage to tube sheets and other tubes.
 - b. Material: **[Copper][or][copper-nickel alloy]<Insert material>**.

- c. Minimum Wall Thickness: **[Manufacturer's choice]<Insert dimension>**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Manufacturer's standard.
2. Water Boxes:
- a. Carbon-steel construction; arranged to allow visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard type.
 - c. Water boxes with lifting lugs or eyebolts.
 - d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with **[3/4-inch (19-mm)][or][1-inch (25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.

N. Solution Heat Exchanger:

- 1. Description: Shell-and-tube or brazed-plate heat exchanger, integral to chiller, to increase cycle efficiency by preheating diluted solution on its way to generator while precooling concentrated solution returning from generator.

O. Burner Assembly:

- 1. Burner: Welded construction with multivane, stainless steel, flame-retention diffuser suitable for **[natural gas][propane][and][No. 2 fuel oil]**. **[Mount burner on hinged access door to permit access to combustion chamber.]**
- 2. Combustion-Air Blower: Centrifugal fan integral to burner, directly driven by motor; with adjustable damper assembly and locking quadrant to set air-fuel ratio.
 - a. Motors: Comply with requirements specified in Section 230500 "Common Work Results for HVAC."
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- 3. Fuel-Oil Supply: Control devices and modulating control sequence suitable to comply with requirements of **[ASME CSD-1][FM Global][UL]**.
 - a. Fuel-Oil Pump: Two-stage, gear-type oil pump capable of producing **300-psig (2070-kPa)** discharge pressure and **15-in. Hg (50.7-kPa)** vacuum.
 - b. Fuel-Oil Piping Specialties:
 - 1) Suction-line, manual, gate valve.
 - 2) Removable-mesh oil strainer.
 - 3) **0- to 30-in. Hg (0- to 101.3-kPa)** vacuum; **0- to 30-psig (0- to 207-kPa)** vacuum-pressure gauge.
 - 4) **0- to 300-psig (0- to 2070-kPa)** oil-nozzle pressure gauge.
 - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
- 4. Fuel-Oil Pilot: **[Intermittent][Interrupted]**-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with **[cadmium sulfide][UV scanner][Optical]** flame-safety control.
- 5. Gas Train: Control devices and modulating control sequence to comply with requirements of **[ASME CSD-1][FM Global][UL]**.



6. Gas Pilot: **[Intermittent][Interrupted]**-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
7. Equip burner assembly to limit nitrogen oxide emissions to **[20][30]<Insert value>** ppm.

P. Electrical:

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to **[fused disconnect switch][nonfused disconnect switch][circuit breaker]**. Provide electrical devices with minimum withstand rating as required by electrical power distribution system, but not less than **[42,000][65,000]<Insert number>** A.
 - a. Branch power circuit to each motor, dedicated electrical load, and to controls **[with disconnect switch or circuit breaker]**.
 - 1) NEMA KS 1, heavy-duty fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.
 - 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
 - b. NEMA ICS 2, Class A, full-voltage, non-reversing motor controller, with hand-off-auto switch, and overcurrent protection for each motor.
 - c. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered **[and color-coded]**wiring to match wiring diagram. Include spare wiring terminal block for connection to external controls or equipment.
4. Wiring Outside of Enclosures: Factory installed in metal raceway except make terminal connections with not more than **24-inch (610-mm)** length of **[liquidtight][or][flexible metallic]** conduit. Coordinate conduit requirements with requirements in Section 260533.13 "Conduits for Electrical Systems."

Q. Controls:

1. Provide chiller control panel separate from burner control panel.
2. Burner Control Panel: Factory **[or field]** mounted. Maintains safe operating conditions, burner safety limits, burner operation, and interface with chiller controls; include following components:
 - a. On-off switch.
 - b. Flame safeguard.
 - c. Contacts for remote monitoring of flame failure.
 - d. Contacts for proof of combustion-air flow.
 - e. Exhaust gas temperature limit switch.
 - f. Control-circuit transformer.
 - g. Burner motor controls.
 - h. Fuel-oil pump controls, if chiller is equipped with fuel-oil pump.
 - i. Visual indication of on/off status of ignition, blower, and main fuel.
 - j. Alarm bell.
3. Controls: Standalone and microprocessor based, with programs and configuration settings stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
4. Enclosure: Unit mounted, NEMA 250, **[Type 1][Type 3R][Type 4][Type 4x]<Insert type>**, with **[hinged][or][lockable]** cover.
5. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. Display following information in either imperial or metric units selectable through interface:

- a. Date and time.
 - b. Operating or alarm status.
 - c. Cumulative operating hours.
 - d. Outdoor-air temperature if required for chilled-water temperature reset.
 - e. Operating set points for temperature and pressure.
 - f. Entering and leaving temperatures of chilled and condenser water.
 - g. Refrigerant temperature.
 - h. Solution concentration and temperature.
 - i. Indication of solution and purge-pump operation.
 - j. Generator shell pressure.
 - k. Number of starts.
 - l. Number of purge cycles.
 - m. Entering and leaving hot-water temperatures.
 - n. Burner firing rate displayed in percent.
 - o. **<Insert status display items>.**
6. Control Functions:
 - a. Manual or automatic startup and shutdown time schedule.
 - b. Automatic cycle to prevent crystallization.
 - c. Entering and leaving chilled-water temperatures and control set points. Reset chilled-water temperature set point based on **[return-water][outdoor-air][space]<Insert condition>** temperature.
 - d. Entering and leaving hot-water temperatures and control set points. Reset hot-water temperature based on **[return-water][outdoor-air][space]<Insert condition>** temperature.
 - e. Condenser-liquid temperature.
 - f. Measure and record cooling provided and heating energy consumed within programmable time periods, minimum monthly.
 - g. Measure and record heating provided and heating energy consumed within programmable time periods, minimum monthly.
 - h. **<Insert control functions>.**
7. Capacity Control: Automatically controls burner firing rate to maintain chilled-water temperature set point for cooling loads and heating-water temperature set point for heating loads ranging from **[30]<Insert number>** to 100 percent.
8. Safety Shutdowns: To automatically shut down chiller and require manual reset before restart. Display message following each safety shutdown.
 - a. Crystallization.
 - b. Low refrigerant temperature.
 - c. Loss of chilled- or condenser-water flow.
 - d. Low leaving chilled-water temperature, **[2 deg F (1 deg C) below set point]<Insert condition>.**
 - e. First-stage generator low-solution level.
 - f. First-stage generator high temperature or pressure.
 - g. Burner alarm or control malfunction.
 - h. Power failure.
 - i. Solution pump overloads.
 - j. External auxiliary safety shutdown.
 - k. High solution concentration.
 - l. Incomplete dilution cycle.
 - m. **<Insert conditions>.**
9. Warning Conditions: Provide controls to keep chiller operational, but inhibit burner firing rate to prevent safety shutdown. Provide control panel with warning alarm contacts and display message

when any of following operating conditions are detected:

- a. Low refrigerant temperature.
 - b. High generator temperature or pressure.
 - c. High or low entering condenser-water temperature.
 - d. Solution temperature sensor failure.
 - e. Low chilled-water flow.
 - f. Purge-pump current overload.
 - g. **<Insert warning conditions>.**
10. Cycling Shutdowns: Permit automatic restart when preprogrammed limits are reached. Display message following each cycle shutdown.
- a. Cooling Mode:
 - 1) Loss of condenser-water flow.
 - 2) Low leaving chilled-water temperature.
 - 3) Power failure.
 - 4) **<Insert conditions>.**
 - b. Heating Mode:
 - 1) Loss of hot-water flow.
 - 2) High leaving hot-water temperature.
 - 3) Power failure.
 - 4) **<Insert conditions>.**
11. Trending: Capability to trend analog data up to five parameters simultaneously over adjustable period and frequency of polling.
12. Security Access: Provide electronic security access to controls through identification and password with at least three levels of security: view only; view and operate; and view, operate, and service.
13. Control Authority: At least four conditions: off, local manual control at chiller, local automatic control at chiller, and automatic control through remote source.
14. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting printer **[or][electronic monitoring device]**.
15. BAS Interface: Factory-installed hardware and software to enable BAS to monitor, control, and display chiller status and alarms.
- a. Hardwired Points:
 - 1) Monitoring: On-off status, **[common trouble alarm]<Insert monitoring point>.**
 - 2) Control: On-off operation, **[chilled-water, discharge temperature set-point adjustment][hot-water, discharge temperature set-point adjustment]<Insert control point>.**
 - b. Provide **[ASHRAE 135 (BACnet)][LonTalk][Modbus]<Insert type of interface>** for communication interface with BAS to enable BAS operator to control and monitor chiller from remote operator workstation. Provide for control features and monitoring points displayed locally at chiller control panel to be available through BAS.
- R. Finish:
1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

- a. Provide at least one coat of primer with total dry film thickness of at least **2 mils (0.05 mm)**.
 - b. Provide at least two coats of **[alkyd-modified, vinyl enamel][epoxy][polyurethane]** finish with total dry film thickness of at least **4 mils (0.10 mm)**.
 - c. Paint surfaces that are to be insulated before applying insulation.
 - d. Paint installed insulation to match adjacent uninsulated surfaces.
 - e. Color of finish coat to be **[manufacturer's standard][custom color selected by Architect]<Insert color description>**.
2. Furnish Owner with quart container of paint used in application of topcoat to use in touchup applications after Project closeout.
- S. Accessories:
1. Sight Glasses: Equip unit with sight glasses for visual inspection of absorbent solution and refrigerant levels. Provide at least one sight glass in absorber and evaporator sections.
 2. Flow Switches:
 - a. Furnish chiller-manufacturer-supplied flow switch for each **[condenser][evaporator and condenser]** and verify field-mounting location before installation.
 - b. Paddle Flow Switches:
 - 1) Vane operated to actuate double-pole, double-throw switch with one pole field wired to chiller control panel and other pole field wired to BAS.
 - 2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with 10 A rating at 120 V ac.
 - 3) Pressure rating equal to pressure rating of heat exchanger.
 - 4) Construct body and wetted parts of Type 316 stainless steel.
 - 5) House switch in NEMA 250, **[Type 4]<Insert type>** enclosure constructed of die-cast aluminum.
 - 6) Vane length to suit installation.
 - c. Pressure Differential Switches:
 - 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
 - 2) Performance: Switch suitable to withstand, without damage, full-pressure rating of heat exchanger applied to either port and exhibit no set point shift due to variation in working pressure.
 - 3) Set Point: Screw type, field adjustable.
 - 4) Electrical Connections: Internally mounted, screw-type terminal blocks.
 - 5) Switch Enclosure: NEMA 250, **[Type 4]<Insert type>**.
 - 6) Switch Action: Double-pole, double-throw switch with one pole field wired to chiller control panel and other pole field wired to BAS.
 3. Vibration Isolation:
 - a. Chiller-manufacturer-furnished, neoprene-pad vibration isolation for each chiller.
 - b. Two layers of **0.375-inch- (10-mm-)** thick, ribbed- or waffle-pattern neoprene pads separated by 16-gauge, stainless steel plate.
 - c. Fabricate pads from 40- to 50-durometer neoprene.
 - 1) Provide stainless steel square bearing plate to load pad uniformly between **20 and 40 psi (138 and 276 kPa)** with **0.12- to 0.16-inch (3- to 4-mm)** deflection.

2.5 HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM

- A. Provide brush-cleaning system for field installation on each chiller **[condenser]<Insert heat exchanger>** for tube cleaning and improved heat transfer.
- B. Cleaning system to maintain tube fouling at or below design conditions without interrupting normal equipment operation.
- C. System consisting of brush inserted in each tube and catch basket attached to each end of tube. Four-way valve that operates to reverse direction of water flow to push brush through tube while removing tube deposits. Control four-way reversing valve actuator by preset time cycle that provides regular tube brushing during equipment operation. Program frequency of brushing cycle to match Project requirements.
- D. Components:
 - 1. Brush: Each brush to have nylon bristles, titanium wires, and polypropylene tips. Select brush diameter for interference fit with ID of tube not exceeding **0.025 inch (0.6 mm)**.
 - 2. Basket: Single-piece polypropylene basket with neck OD to press fit ID of tube. Design to allow for insertion of eddy current probe or removal of brush without removing basket from valve.
 - 3. Four-Way Valve:
 - a. Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
 - b. Configure valve with parallel flow connections to minimize field installation piping.
 - c. Construct valve to comply with ASME Boiler and Pressure Vessel Code, at system working pressure equal to condenser.
 - d. Provide flanged pipe connections.
 - e. Valve manufacturer to test and certify maximum leakage rate of 0.05 percent of design flow rate at operating conditions with maximum differential pressure.
 - f. Hydrostatically test valve to 1.5 times design working pressure.
 - g. Design valve to cause no more than **0.5-psig (3-kPa)** pressure drop at design flow conditions.
 - h. Provide valve with valve-mounted indicating/warning light, that energizes before valve begins rotation.
 - i. Valve Actuator:
 - 1) Provide actuator to operate valve. Coordinate actuator power and signal requirements with control system and valve operating requirements.
 - 2) Mount pneumatic piston-type actuator to operate valve. Actuator is suitable for operation with field-supplied air pressure.
 - j. Position Switches: Factory mount limit switches on valve to indicate complete rotation of valve in both normal and reverse flow.
 - 4. Control Panel: Factory or field mount control panel including the following features on chiller:
 - a. NEMA 250, **[Type 1][Type 4][Type 4x][Type 12]** enclosure.
 - b. Timer to automatically initiate cleaning cycle over 24-hour period.
 - c. Manual override of preset cleaning cycle.
 - d. Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction," indicating slow or incomplete valve turn.
 - e. For pneumatic actuators, mount four-way solenoid valve in control panel for control valve actuator operation.
 - f. Flow-switch bypass.

- g. Unloading signal to chiller.

2.6 SOURCE QUALITY CONTROL

- A. Perform functional **[run]**tests of chillers before shipping.
- B. Factory test and inspect absorber, generator, evaporator, and condenser in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test tube-side of heat exchangers, including water boxes, to 1.5 times rated pressure. Vacuum and pressure test shells for leaks.
- C. Burner Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion requirements indicated.
- D. Factory Performance Testing: Test chillers, before shipping, in accordance with AHRI 560.
1. Test the following conditions:
- a. Design conditions indicated.
- b. Reduction in capacity from design to minimum load in steps of **[10][25][33]<Insert number>** percent with condenser liquid at design conditions.
- c. Reduction in capacity from design to minimum load in steps of **[10][25][33]<Insert number>** percent with varying entering condenser-liquid temperature from design to minimum conditions in **[5 deg F (3 deg C)]<Insert temperature>** increments.
- d. At **[one][two][three][four][five][10]<Insert number>** point(s) of varying part-load performance to be selected by Owner at time of test.
- E. Factory Sound Testing: Test chillers, before shipping, in accordance with AHRI 575.
1. Test the following conditions:
- a. Design conditions indicated.
- b. Chiller operating at calculated worst-case sound condition.
- c. At **[one][two][three][four][five]<Insert number>** point(s) of full and varying part-load performance to be selected by Owner at time of test.
- F. Allow **[Owner]<Insert entity>** access to place where chillers are being tested. Notify Architect **[14]<Insert number>** days in advance of testing.
- G. Prepare and submit test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine chillers before installation. Reject chillers that are physically damaged.
- B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.
1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before

roughing-in for piping and electrical connections.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF DIRECT-FIRED ABSORPTION WATER CHILLERS

- A. Install chillers on support structure indicated.
- B. Equipment Mounting:
 - 1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Maintain manufacturer's recommended clearances for service and maintenance.
- D. Charge chiller with absorbent and refrigerant if not factory charged.
- E. Install separate devices furnished by manufacturer and not factory installed.
- F. Insulate hot and cold chiller surfaces that are recommended by chiller manufacturer to be insulated, and are not factory insulated. Comply with requirements in Section 230716 "HVAC Equipment Insulation."

3.3 INSTALLATION OF HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM

- A. Install brush-cleaning system control panel adjacent to chiller control panel.
- B. Arrange piping to allow service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
- C. Provide field electric power, as required, to each system control panel and electric-actuated valve.
- D. Provide pneumatic piping with pressure regulator and isolation valve at each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
- E. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
- F. Functionally test entire brush-cleaning system, including control valve, control valve actuator, position indicator, and control panel, with chiller in operation.

3.4 PIPING CONNECTIONS

- A. Comply with requirements for hydronic piping in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for gas piping in [Section 231123 "Facility Natural-Gas

Piping"][or]**[Section 231126 "Facility Liquefied-Petroleum Gas Piping."**] Drawings indicate general arrangement of piping, fittings, and specialties.

- C. Connect fuel gas piping full size to gas-train inlet with shutoff valve and union.
- D. Extend burner fuel train vent to suitable outdoor location, away from operable windows and air intakes.
- E. Install gas-fired boilers in accordance with NFPA 54.
- F. Comply with requirements for fuel-oil piping in Section 231113 "Facility Fuel-Oil Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- G. Connect oil piping full size to burner inlet with shutoff valve and union.
- H. Install oil-fired chillers in accordance with NFPA 31.
- I. Where installing piping adjacent to chiller, allow space for service and maintenance.
- J. Hot-Water Heat-Exchanger Connections: Connect to heat-exchanger inlet with shutoff valve, **[strainer,][flexible connector,]** thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to heat-exchanger outlet with shutoff valve, check valve, balancing valve,**[flexible connector,]** flow switch, thermometer, plugged tee with shutoff valve and pressure gauge,**[flow meter,]** and drain connection with valve. Make connections to chiller with **[flange][or][mechanical coupling]**.
- K. Evaporator-Liquid Connections: Connect to evaporator inlet with shutoff valve, **[strainer,][flexible connector,]** thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to evaporator outlet with shutoff valve, balancing valve,**[flexible connector,]** flow switch, thermometer, plugged tee with shutoff valve and pressure gauge,**[flow meter,]** and drain connection with valve. Make connections to chiller with **[flange][or][mechanical coupling]**.
- L. Absorber/Condenser-Liquid Connections: Connect to inlet with shutoff valve, **[strainer,][flexible connector,]** thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to outlet with shutoff valve, balancing valve,**[flexible connector,]** flow switch, thermometer, plugged tee with shutoff valve and pressure gauge,**[flow meter,]** and drain connection with valve. Make connections to chiller with **[flange][or][mechanical coupling]**.
 - 1. If not factory furnished or installed, provide pipe connecting liquid connection of absorber discharge and condenser inlet.
- M. Refrigerant Pressure Relief Device Connections: Extend **[vent piping][separate vent piping for each chiller]** without valves or restrictions to outdoor location. Comply with ASHRAE 15 and ASHRAE 34. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.
- N. Extend **[purge vent piping][separate purge vent piping for each chiller]** to outdoor location. Comply with ASHRAE 15 and ASHRAE 34.
- O. Connect each chiller drain connection with union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.
- P. Comply with requirements for chimney system in Section 235133 "Insulated Sectional Chimneys" and Section 235116 "Fabricated Breechings and Accessories." Drawings indicate general arrangement of pipe, fittings, and specialties. Connect chimney system to chiller burner outlet and extend to outdoor location.
- Q. Connect fuel-fired burner assembly and blower and associated damper for combustion air.

3.5 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished with chiller but not factory mounted.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between control devices.
- C. Connect control wiring in accordance with Section 260523 "Control Voltage Electrical Power Cables."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections **[with the assistance of a factory-authorized service representative]**.
- D. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Absorption water chillers will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.8 STARTUP SERVICE

- A. **[Engage factory-authorized service representative to perform][Perform]** startup service.
1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Verify that absorbent and refrigerant charge is sufficient and chiller has been leak tested.
 3. Verify that pumps are installed and functional.
 4. Verify that thermometers and gauges are installed.
 5. Verify that refrigerant pressure relief device is vented to outdoors.
 6. Verify proper motor rotation.
 7. Operate chiller for run-in period.
 8. Verify proper fuel supply. Adjust air-fuel ratio and combustion.
 9. Verify proper combustion-air source.
 10. Verify proper exhaust emissions.
 11. Verify static deflection of vibration isolators including deflection during chiller startup and shutdown.
 12. Verify and record performance of liquid flow and low-temperature interlocks for evaporator and condenser.
 13. Verify and record performance of chiller protection devices.
 14. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
 15. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
- C. Prepare test and inspection startup reports.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain chillers. **[Video record training sessions.]**

END OF SECTION 23 64 13 00



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 64 13 16 - INDIRECT-FIRED ABSORPTION WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Indirect-fired absorption water chillers.
 2. Heat-exchanger, brush-cleaning system.

1.2 DEFINITIONS

- A. BAS: Building automation system.
- B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- C. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 560 and referenced to AHRI standard rating conditions.
- D. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 560 and intended for operating conditions other than the AHRI standard rating conditions.

1.3 ACTION SUBMITTALS

- A. Product Data: For the following:
1. Indirect-fired absorption water chillers.
 2. Heat-exchanger, brush-cleaning system.
- B. Product Data Submittals: For each type of product. Include rated capacities, operating characteristics, furnished specialties and accessories, and the following:
1. Performance at AHRI standard conditions and at conditions indicated.
 2. Performance at AHRI standard unloading conditions.
 3. Minimum evaporator flow rate.
 4. Absorbent capacity of chiller.
 5. Refrigerant capacity of chiller.
 6. Liquid capacity of evaporator and condenser.
 7. Liquid capacity of generator.
 8. Characteristics of safety relief devices.
 9. Minimum entering condenser-liquid temperature.
 10. Performance at varying capacities with constant design condenser-liquid temperature. Repeat performance at varying capacities for different condenser-liquid temperatures from design to minimum in [5 deg F (3 deg C)]<Insert temperature> increments.
- C. Sustainable Design Submittals:

1. Product Data: For energy performance.

D. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Insulated Surface Diagrams: Indicating cold and hot surfaces requiring field-applied insulation with area tabulated for each.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Seismic Qualification Data: Certificates, for chillers, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Source quality-control reports.
- D. Startup service reports.
- E. Test and inspection startup reports.
- F. Field quality-control reports.
- G. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Ship chillers factory charged with nitrogen.
- B. Ship absorbent and refrigerant in chillers or in containers separate from chillers.
- C. Ship **[absorbent][and][refrigerant]** in containers separate from chillers.
- D. Package chiller for export shipping in totally enclosed **[bagging][crate][crate with bagging]**.



1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
- B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
 - 1. Extended warranties include, but are not limited to, the following:
 - a. Complete chiller.
 - b. **[Pumps and motors][Purge unit]<Insert components>.**
 - c. **[Absorbent][Absorbent and refrigerant] only.**
 - d. Parts **[only][and labor].**
 - e. Loss of absorbent and refrigerant for any reason.
 - 2. Warranty Period: **[One][Two][Three][Four][Five]<Insert number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain chillers from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. AHRI Rating: Rate chiller performance in accordance with requirements in AHRI 560.
- B. ASHRAE Compliance:
 - 1. ASHRAE 15 and ASHRAE 34 for safety code for mechanical refrigeration.
 - 2. ASHRAE/IES 90.1.
- C. ASME Compliance: Fabricate and label chiller pressure vessels to comply with applicable portions of ASME Boiler and Pressure Vessel Code.
- D. Comply with NFPA 70.
- E. UL Compliance:
 - 1. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.
- F. Seismic Performance: Indirect-fired absorption water chillers are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>.**

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."

G. Condenser-Liquid Temperature Performance:

1. Startup Condenser-Liquid Temperature: Provide chiller capable of starting with entering condenser-liquid temperature of **[64 deg F (17.7 deg C)][45 deg F (7.2 deg C)]<Insert temperature>** and providing stable operation until system temperature is elevated to minimum operating entering condenser-liquid temperature.
2. Minimum Operating Condenser-Liquid Temperature: Provide chiller capable of continuous operation over entire capacity range indicated with an entering condenser-liquid temperature of **[65 deg F (18 deg C)][60 deg F (16 deg C)][55 deg F (13 deg C)]**.
3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

H. Site Altitude: Provide chiller suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

I. Performance Tolerance: Comply with following in lieu of AHRI 560:

1. Allowable Capacity Tolerance: **[Zero]<Insert number>** percent.
2. Allowable IPLV/NPLV Performance Tolerance: **[Zero]<Insert number>** percent.

2.3 CAPACITIES AND CHARACTERISTICS

A. Capacity: **<Insert tons (kW)>**.

B. Full-Load Efficiency (COP): **<Insert number>**.

C. Part-Load Efficiency:

1. IPLV: **<Insert number>**.
2. NPLV: **<Insert number>**.

D. Evaporator:

1. Pressure Rating: **[150 psig (1035 kPa)][300 psig (2070 kPa)]<Insert number>**.
2. Number of Passes: **[One][Two][Three]<Insert number>**.
3. Liquid Type: **[Water]<Insert liquid type>**.
4. Design Liquid Flow Rate: **<Insert gpm (L/s)>**.
5. Minimum Liquid Flow Rate: **<Insert gpm (L/s)>**.
6. Entering-Liquid Temperature: **<Insert deg F (deg C)>**.
7. Leaving-Liquid Temperature: **<Insert deg F (deg C)>**.
8. Liquid Pressure Drop: **<Insert feet of head (kPa)>**.
9. Liquid Velocity: **<Insert fps (m/s)>**.
10. Fouling Factor: **[0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000045 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert value>**.

E. Absorber/Condenser:

1. Pressure Rating: **[150 psig (1035)][300 psig (2070)]<Insert number>**.
2. Number of Passes: **[One][Two][Three]**.

3. Liquid Type: **[Water]<Insert liquid type>**.
4. Design Liquid Flow Rate: **<Insert gpm (L/s)>**.
5. Entering-Liquid Temperature: **<Insert deg F (deg C)>**.
6. Leaving-Liquid Temperature: **<Insert deg F (deg C)>**.
7. Liquid Pressure Drop: **<Insert feet of head (kPa)>**.
8. Liquid Velocity: **<Insert fps (m/s)>**.
9. Fouling Factor: **[0.00025 sq. ft. x h x deg F/Btu (0.000045 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)][0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W)]<Insert value>**.

F. Pump Horsepower:

1. Purge: **<Insert number>**.
2. Refrigerant: **<Insert number>**.
3. Solution: **<Insert number>**.

G. Chiller Control Electrical Requirements:

1. Power Input: **<Insert kilowatts>**.
2. Minimum Circuit Ampacity: **<Insert value> A**.
3. Maximum Overcurrent Protection Device: **<Insert value> A**.
4. Characteristics: **[120]<Insert number> V ac, single phase, 60 Hz**.

H. Chiller Electrical Requirements:

1. Power Input: **<Insert kilowatts>**.
2. Minimum Circuit Ampacity: **<Insert value> A**.
3. Maximum Overcurrent Protection Device: **<Insert value> A**.
4. Characteristics: **[208][240][480]<Insert number> V ac, three phase, 60 Hz**.

- I. Noise Rating: **[38][51][80]<Insert dBA>** sound power level when measured in accordance with AHRI 575. Provide factory-installed sound treatment if necessary to achieve performance indicated.

2.4 INDIRECT-FIRED ABSORPTION WATER CHILLERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Carrier Global Corporation]**
2. **[Trane / Thermax]**
3. **[Yazaki Energy Systems]**
4. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
5. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Carrier Global Corporation]**
2. **[Trane / Thermax]**
3. **[Yazaki Energy Systems]**
4. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
5. **<Insert manufacturer's name>**

- C. Description: Factory-assembled and -tested, hermetic-design chiller complete with absorber,

evaporator, condenser, generator, solution heat exchanger, controls, absorbent solution pump with motor, refrigerant pump with motor, purge unit with motor, motor controllers, rupture disk, interconnecting unit piping and wiring, indicated accessories, and mounting frame.

1. Disassemble chiller into major assemblies as required for installation, after factory testing and before packaging for shipment.

D. Absorbent and Refrigerant:

1. Absorbent: Lithium bromide solution with corrosion inhibitor.
2. Refrigerant: Deionized **[or][distilled]** water.
3. Performance Enhancer: Heat and mass transfer enhancer to improve performance.

E. Seismic Fabrication Requirements: Fabricate mounting base and attachment to chiller, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

F. Pumps:

1. Hermetically sealed, self-lubricating, and fitted with self-adjusting, spring-loaded, wear-compensating tapered carbon bearings.
2. Provide pump motor assembly designed to operate for not less than **[25,000][50,000]** hours between inspections.
3. Pump motors cooled, and bearings lubricated, either by liquid being pumped.
4. Provide isolation valves at pump suction and discharge.
5. Provide separate and dedicated pumps for absorbent solution and refrigerant.
 - a. Provide chiller manufacturer's recommended absorbent solution and refrigerant flow-control method, to comply with operating requirements indicated.
6. Purge System: Unit mounted and factory wired, equipped with controls and pump to automatically remove noncondensable vapors.
 - a. Purge Pump Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 1) Enclosure: **[Open dripproof][or][totally enclosed]**.

G. Heat-Exchanger Shells:

1. Configuration for Single-Effect Chillers: Two shells; one shell consists of absorber/evaporator and other shell consists of condenser/generator.
2. Configuration for Double-Effect Chillers: Two shells; one shell consists of absorber/evaporator, low-stage generator/condenser and other shell consists of high-stage generator.
3. Construction: Fabricated from continuously welded carbon-steel sheet or plate, or from seamless pipe.
4. Design Pressure and Temperature Rating: Comply with applicable requirements in ASME Boiler and Pressure Vessel Code.
5. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between liquid in tubes and refrigerant in shell.
6. Intermediate Tube Sheets: Carbon-steel plates installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
7. Generator/Condenser Shell Pressure Relief Device: Manufacturers standard rupture disk

complying with requirements in ASHRAE 15 and ASHRAE 34 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

H. Absorber:

1. Nozzle or Dispersion Trays: Designed to evenly distribute absorbent solution over tubes. Constructed of brass, stainless steel, or another material that will not corrode.
2. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
 - b. Material: **[Copper][Copper-nickel alloy][Stainless steel][Titanium][Copper, copper-nickel alloy, stainless steel, or titanium]<Insert material>**.
 - c. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: **[Enhanced][or][smooth]**.
3. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Water Box with Piping Connections: **[Standard][Marine]** type.
 - 1) Water boxes **[and marine water-box covers]**with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - 3) Hinged marine water-box covers.
 - c. Water Box without Piping Connections: Standard type.
 - 1) Water boxes with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with **[3/4-inch (19-mm)][or][1-inch (25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.
4. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
 - c. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with corrosion-resistant finish.
5. Absorber/Condenser Crossover Piping: Factory furnished and installed piping connecting liquid connection of absorber discharge to condenser inlet.

I. Evaporator:

1. Nozzle or Dispersion Trays: Designed to evenly distribute refrigerant over tubes; constructed of brass, stainless steel, or another material that will not corrode when exposed to absorbent.
2. Refrigerant Holding Pan: Steel or stainless steel.
3. Tubes:

- a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes, and integrity of tube-tube sheet connections.
 - b. Material: **[Copper][Copper-nickel alloy][Stainless steel][Titanium][Copper, copper-nickel alloy, stainless steel, or titanium]<Insert material>**.
 - c. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: **[Enhanced][or][smooth]**.
4. Water Boxes:
- a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Water Box with Piping Connections: **[Standard][Marine]** type.
 - 1) Water boxes **[and marine water-box covers]**with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - 3) Hinged marine water-box covers.
 - c. Water Box without Piping Connections: Standard type.
 - 1) Water boxes with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - 3) Hinged marine water-box covers.
 - d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with **[3/4-inch (19-mm)][or][1-inch (25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.
- J. Condenser:
1. Refrigerant Holding Pan: Steel or stainless steel.
 2. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
 - b. Material: **[Copper][Copper-nickel alloy][Stainless steel][Titanium][Copper, copper-nickel alloy, stainless steel, or titanium]<Insert material>**.
 - c. Minimum Wall Thickness: **[Manufacturer's choice]<Insert inches (mm)>**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: **[Enhanced][or][smooth]**.
 3. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Water Box with Piping Connections. **[Standard][Marine]** type.
 - 1) Water boxes **[and marine water-box covers]**with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - 3) Hinged marine water-box covers.

- c. Water Box without Piping Connections: Standard type.
 - 1) Water boxes with lifting lugs or eyebolts.
 - 2) Hinged water boxes.
 - 3) Hinged marine water-box covers.
 - d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with **[3/4-inch (19-mm)][or][1-inch (25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.
4. Additional Corrosion Protection:
- a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
 - c. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with corrosion-resistant finish.
- K. Generator for Single-Effect Chillers:
1. Tubes:
- a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
 - b. Material: **[06/11 copper-nickel alloy][Stainless steel][Titanium][06/11 copper-nickel alloy, stainless steel, or titanium]<Insert material>**.
 - c. Minimum Wall Thickness: **[Manufacturer's choice][0.035 inch (0.9 mm)]<Insert dimension>**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: **[Enhanced][or][smooth]**.
2. Water Boxes:
- a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard type.
 - c. Provide water boxes with lifting lugs or eyebolts.
 - d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with **[3/4-inch (19-mm)][or][1-inch (25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.
3. Additional Corrosion Protection:
- a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
 - c. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
- L. First-Stage Generator for Double-Effect Chillers:
1. Tubes:

- a. Replaceable, straight, or U tubes expanded into tube sheets.
- b. Material: **[Manufacturer's standard][06/11 copper-nickel alloy][Type 409 stainless steel][Titanium][06/11 copper-nickel alloy, Type 409 stainless steel]<Insert material>**.
- c. Minimum Wall Thickness: **[Manufacturer's choice][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>**.
- d. External Finish: Manufacturer's standard.
- e. Internal Finish: **[Enhanced][or][smooth]**.

2. Water Boxes:

- a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
- b. Standard type.
- c. Provide water boxes with lifting lugs or eyebolts.
- d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
- e. Thermistor or RTD temperature sensor factory installed in each nozzle.
- f. Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.

3. Additional Corrosion Protection:

- a. Electrolytic corrosion-inhibitor anode.
- b. Coat wetted surfaces with a corrosion-resistant finish.
- c. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

M. Second-Stage Generator for Double-Effect Chillers:

1. Tubes:

- a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
- b. Material: **[Copper][Copper-nickel alloy][Copper or copper-nickel alloy][Stainless steel][Titanium]<Insert material>**.
- c. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>**.
- d. External Finish: Manufacturer's standard.
- e. Internal Finish: **[Enhanced][or][smooth]**.

2. Water Boxes:

- a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
- b. Standard type.
- c. Provide water boxes with lifting lugs or eyebolts.
- d. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
- e. Thermistor or RTD temperature sensor factory installed in each nozzle.
- f. Fit each water box with **[3/4-inch (19-mm)][or][1-inch (25-mm)]<Insert dimension>** drain connection at low point and vent connection at high point, each with threaded plug.

3. Additional Corrosion Protection:

- a. Electrolytic corrosion-inhibitor anode.
- b. Coat wetted surfaces with a corrosion-resistant finish.
- c. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

N. Solution Heat Exchanger:

1. Description: Shell-and-tube or brazed-plate heat exchanger; integral part of chiller to increase cycle efficiency by preheating weak solution on its way to generator while precooling strong solution returning from generator.

O. Steam Condensate Drain Cooler:

1. Description: Shell-and-tube heat exchanger constructed of carbon-steel shell and copper-nickel-alloy or stainless steel tubes.

P. Factory-Applied Insulation:

1. Factory-Applied Insulation on Cold Surfaces:

- a. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C534/C534M, Type I for tube and Type II for sheet materials.
 - 1) Thickness: **[3/4 inch (19 mm)][1-1/2 inches (38mm)]<Insert dimension>**.
- b. Adhesive: As recommended by insulation manufacturer.
- c. Factory apply insulation over all cold surfaces of chiller capable of forming condensation. Insulated components include, but are not limited to, evaporator shell and end tube sheets; evaporator water boxes including nozzles; refrigerant pump; cold surfaces of motor; and cold piping.
 - 1) Apply adhesive to 100 percent of insulation contact surface.
 - 2) Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
 - 3) Seal seams and joints to provide a vapor barrier.
 - 4) After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

2. Factory-Applied Insulation on Hot Surfaces:

- a. Mineral-fiber board, pipe, or tank insulation complying with one of the following:
 - 1) ASTM C547, Type I or Type II, Grade A.
 - 2) ASTM C612, Type IB.
 - 3) ASTM C1393, Type II or Type IIIA, Category 2.
 - 4) Thickness: **[1-1/2 inches (38 mm)][2 inches (50mm)]<Insert dimension>**.
- b. Adhesive: As recommended by insulation manufacturer.
- c. Factory apply materials over all hot surfaces to provide smooth, straight, and even surfaces; free of voids.
 - 1) Apply adhesive to insulation contact surface as recommended by insulation manufacturer.
 - 2) Install insulation anchor pins and washers if required by insulation manufacturer to

- secure insulation to surfaces to be insulated.
- 3) Completely encapsulate insulation with metal jacket, leaving no exposed insulation. Provide removable jacket on components requiring access for service and inspection.
- 4) Paint exposed surfaces of metal jacket to match other painted parts unless jacket material is aluminum or stainless steel.

Q. Electrical:

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to **[fused disconnect switch][nonfused disconnect switch][circuit breaker]**. Provide devices with minimum withstand rating as required by electrical power distribution system, but not less than **[42,000][65,000]<Insert number> A**.
 - a. Branch power circuit to each motor, dedicated electrical load, and controls **[with disconnect switch or circuit breaker]**.
 - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.
 - 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
 - b. NEMA ICS 2, Class A, full-voltage, nonreversing motor controller, hand-off-auto switch, and overcurrent protection for each motor.
 - c. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered **[and color-coded]** wiring to match wiring diagram. Include spare wiring terminal block for connection to external controls or equipment.
4. Wiring Outside of Enclosures: Factory installed in metal raceway except make terminal connections with not more than a **24-inch (610-mm)** length of **[liquidtight][or][flexible metallic]** conduit. Coordinate conduit requirements with requirements in Section 260533.13 "Conduits for Electrical Systems."

R. Controls:

1. Control: Standalone and microprocessor based, with programs and configuration settings stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
2. Enclosure: Unit mounted, NEMA 250, **[Type 1][Type 3R][Type 4][Type 4x]<Insert type>**, hinged or lockable.
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. Display following information in either imperial or metric units selectable through interface.
 - a. Date and time.
 - b. Operating or alarm status.
 - c. Operating hours.
 - d. Outdoor-air temperature if required for chilled-water reset.
 - e. Temperature and pressure of operating set points.
 - f. Entering and leaving temperatures of chilled and condenser water.
 - g. Refrigerant temperature.
 - h. Solution concentration and temperature.
 - i. Indication of solution and purge-pump operation.
 - j. Generator shell pressure.
 - k. Number of starts.

- l. Number of purge cycles.
 - m. Hot-water valve actuator potentiometer position (percentage).
 - n. Entering and leaving hot-water temperatures.
 - o. Steam demand limit.
 - p. Inlet steam pressure and temperature.
 - q. Steam valve actuator potentiometer position (percentage).
 - r. First-stage generator pressure and temperature.
 - s. **<Insert status display items>.**
4. Control Functions:
 - a. Manual or automatic startup and shutdown time schedule.
 - b. Automatic cycle to prevent crystallization.
 - c. Entering and leaving chilled-water temperatures and control set points. Reset chilled-water temperature based on **[return-water][outdoor-air][space]** temperature.
 - d. Condenser-liquid temperature.
 - e. Measure and record cooling provided and heating energy used within programmable time periods, minimum monthly.
 - f. **<Insert control functions>.**
 5. Capacity Control: Automatically controls input flow rate of heat source to maintain chilled-water temperature set point for cooling loads ranging from 10 to 100 percent.
 6. Control Valve Package: **[Factory-furnished, for field installation,][Factory-installed]** control valve package suitable for energy source indicated.
 - a. Body: Cast-iron, carbon-steel, or stainless steel body with flanged connections.
 - b. Type: **[Manufacturer's choice][V-notch ball][Butterfly][Globe style with cage-guide plug]<Insert type>** constructed of stainless steel.
 - c. Rating: Pressure and temperature rating to match heat exchanger.
 - d. Shutoff: Capable of bubble-tight shutoff against maximum system pressure.
 - e. Size: Determined by chiller manufacturer.
 - f. Modulation: **[Two][Three]** way.
 - g. Turndown: As required to achieve stable control through indicated operating range.
 - h. Actuator: Electric powered from chiller control panel and installed on valve.
 7. Safety Shutdowns: To automatically shut down chiller and require manual reset before restart. Display message following each safety shutdown.
 - a. Crystallization.
 - b. Low refrigerant temperature.
 - c. Loss of chilled- or condenser-water flow.
 - d. Low leaving chilled-water temperature[, **2 deg F (1 deg C) below set point**].
 - e. First-stage generator low-solution level.
 - f. First-stage generator high temperature or pressure.
 - g. Power failure.
 - h. Solution pump overloads.
 - i. External auxiliary safety shutdown.
 - j. High solution concentration.
 - k. Incomplete dilution cycle.
 - l. High entering-water temperature.
 - m. High inlet steam pressure and temperature.
 - n. **<Insert conditions>.**
 8. Warning Conditions: Provide control panel that closes warning contacts and generates message when one of the following operating conditions is detected:

- a. Low refrigerant temperature.
 - b. High generator temperature or pressure.
 - c. High entering generator-water temperature (single-stage generator only).
 - d. High or low entering condenser-water temperature.
 - e. Solution temperature sensor failure.
 - f. Low chilled-water flow.
 - g. **<Insert warning conditions>**.
9. Trending: Capability to trend analog data up to five parameters simultaneously over adjustable period and frequency of polling.
10. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
11. Control Authority: At least four conditions: off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
12. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting printer **[or][electronic monitoring device]**.
13. BAS Interface: Factory-installed hardware and software to enable BAS to monitor, control, and display chiller status and alarms.
 - a. Hardwired Points:
 - 1) Monitoring: On-off status, **[common trouble alarm]<Insert monitoring point>**.
 - 2) Control: On-off operation, **[chilled-water, discharge temperature set-point adjustment][generator heat source capacity limiting]<Insert control point>**.
 - b. Provide **[ASHRAE 135 (BACnet)][LonTalk][Modbus]<Insert type of interface>** communication interface with BAS to enable BAS operator to control and monitor chiller from remote operator workstation. Provide for control features and monitoring points displayed locally at chiller control panel to be available through BAS.

S. Finish:

1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
 - a. Provide at least one coat of primer with a total dry film thickness of at least **2 mils (0.05 mm)**.
 - b. Provide at least two coats of **[alkyd-modified, vinyl enamel][epoxy][polyurethane]** finish with a total dry film thickness of at least **4 mils (0.10 mm)**.
 - c. Paint surfaces that are to be insulated before applying insulation.
 - d. Paint installed insulation to match adjacent uninsulated surfaces.
 - e. Color of finish coat to be **[manufacturer's standard][custom color selected by Architect]<Insert color description>**.
2. Furnish Owner with quart container of paint used in application of topcoat to use in touchup applications after Project closeout.

T. Accessories:

1. Sight Glasses: Equip unit with sight glasses for visual inspection of absorbent solution and refrigerant levels. Provide at least one sight glass in absorber and evaporator sections.
2. Flow Switches:
 - a. Furnish chiller-manufacturer-supplied hall flow switch for each **[condenser][evaporator]**

- and condenser]** and verify field-mounting location before installation.
 - b. Paddle Flow Switches:
 - 1) Vane operated to actuate double-pole, double-throw switch with one pole field wired to chiller control panel and other pole field wired to BAS.
 - 2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120 V ac.
 - 3) Pressure rating equal to pressure rating of heat exchanger.
 - 4) Construct body and wetted parts of Type 316 stainless steel.
 - 5) House switch in a NEMA 250, **[Type 4]<Insert type>** enclosure constructed of die-cast aluminum.
 - 6) Vane length to suit installation.
 - c. Pressure Differential Switches:
 - 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
 - 2) Performance: Switch suitable to withstand, without damage, full-pressure rating of heat exchanger applied to either port and exhibit no set-point shift due to variation in working pressure.
 - 3) Set Point: Screw type, field adjustable.
 - 4) Electrical Connections: Internally mounted screw-type terminal blocks.
 - 5) Switch Enclosure: NEMA 250, **[Type 4]<Insert type>**.
 - 6) Switch Action: Double-pole, double-throw switch with one pole field wired to chiller control panel and other pole field wired to BAS.
- 3. Vibration Isolation:
 - a. Chiller-manufacturer-furnished, neoprene-pad vibration isolation for each chiller.
 - 1) Two layers of **0.375-inch- (10-mm-)** thick, ribbed- or waffle-pattern neoprene pads separated by 16-gauge, stainless steel plate.
 - 2) Fabricate pads from 40- to 50-durometer neoprene.
 - 3) Provide stainless steel square bearing plate to load pad uniformly between **20 and 40 psi (138 and 276 kPa)** with **0.12- to 0.16-inch (3- to 4-mm)** deflection.

2.5 HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM

- A. Provide brush-cleaning system on each chiller **[condenser]<Insert heat exchanger>** for tube cleaning and improved heat transfer.
- B. Cleaning system to maintain tube fouling at or below design conditions without interrupting normal equipment operation.
- C. System consisting of brush inserted in each tube and catch basket attached to each end of tube. Four-way valve to reverse direction of water flow to push brush through tube while removing tube deposits. Control four-way reversing valve's actuator by preset time cycle that provides regular tube brushing during equipment operation. Program frequency of brushing cycle to match Project requirements.
- D. Components:
 - 1. Brush: Each brush with nylon bristles, titanium wires, and polypropylene tips. Select brush interference fit with ID of tube not exceeding **0.025 inch (0.6 mm)**.
 - 2. Basket: Single-piece polypropylene basket with neck OD to press fit ID of tube. Design to allow for insertion of eddy current probe or removal of brushes without removing baskets from valve.
 - 3. Four-Way Valve:

- a. Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
 - b. Configure valve with parallel flow connections to minimize field installation piping.
 - c. Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
 - d. Provide flanged pipe connections.
 - e. Valve manufacturer to test and certify maximum leakage rate of less than 0.05 percent of design flow rate at operation conditions of maximum differential pressure.
 - f. Hydrostatically test to 1.5 times design working pressure.
 - g. Design valve to cause no more than **0.5-psig (3-kPa)** pressure drop at design flow conditions.
 - h. Provide valve with valve-mounted indicating/warning light, that energizes before valve begins rotation.
 - i. Valve Actuator, Electric: Provide actuator to operate valve. Coordinate actuator power and signal requirements with control system and valve operating requirements.
 - j. Valve Actuator, Pneumatic: Mount pneumatic piston-type actuator to operate valve. Actuator is suitable for operation using field-supplied air pressure.
 - k. Position Switches: Factory mount microswitches on valve to indicate complete turn of valve in both normal and reverse flow.
4. Control Panel: Factory or field mount control panel including the following features on chiller:
- a. NEMA 250, **[Type 1][Type 4][Type 4x][Type 12]** enclosure.
 - b. Timer to automatically initiate cleaning cycle over a 24-hour period.
 - c. Manual override of preset cleaning cycle.
 - d. Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating slow turn or incomplete valve turn.
 - e. For pneumatic actuators, mount four-way solenoid valve for actuator operation in control panel.
 - f. Flow-switch bypass.
 - g. Unloading signal to chiller.

2.6 SOURCE QUALITY CONTROL

- A. Perform functional **[run]**tests of chillers before shipping.
- B. Factory test and inspect absorber, generator, evaporator, and condenser in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test tube-side of heat exchangers, including water boxes, to 1.5 times rated pressure. Vacuum and pressure test shells for leaks.
- C. Factory Performance Testing: Test chillers, before shipping, in accordance with AHRI 560.
1. Test the following conditions:
 - a. Design conditions indicated.
 - b. Reduction in capacity from design to minimum load in steps of **[10][25][33]<Insert number>** with condenser liquid at design conditions.
 - c. Reduction in capacity from design to minimum load in steps of **[10][25][33]<Insert number>** with varying entering condenser-liquid temperature from design to minimum conditions in **[5 deg F (3 deg C)]<Insert temperature>** increments.
 - d. At **[one][two][three][four][five][10]<Insert number>** point(s) of varying part-load performance to be selected by Owner at time of test.
- D. Factory Sound Testing: Test chillers, before shipping, in accordance with AHRI 575.

1. Test the following conditions:
 - a. Design conditions indicated.
 - b. Chiller operating at calculated worst-case sound condition.
 - c. At **[one][two][three][four][five]<Insert number>** point(s) of varying part-load performance to be selected by Owner at time of test.
- E. Allow **[Owner]<Insert entity>** access to place where chillers are being tested. Notify Architect **[14]<Insert number>** days in advance of testing.
- F. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine chillers before installation. Reject chillers that are damaged.
- B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.
 1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF INDIRECT-FIRED ABSORPTION WATER CHILLERS

- A. Install chillers on support structure indicated.
- B. Equipment Mounting:
 1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Maintain manufacturer's recommended clearances for service and maintenance.
- D. Charge chiller with absorbent and refrigerant if not factory charged.
- E. Install separate devices furnished by manufacturer and not factory installed.
- F. Insulate hot and cold chiller surfaces that are recommended by chiller manufacturer to be insulated, and are not factory insulated. Comply with requirements in Section 230716 "HVAC Equipment Insulation."

3.3 INSTALLATION OF HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM

- A. Install brush-cleaning system control panel adjacent to chiller control panel.
- B. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
- C. Provide field electric power, as required, to each system control panel and electric actuated valve.
- D. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
- E. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
- F. Functionally test entire brush-cleaning system, including valve, actuator, position indicator, and control panel, with chiller in operation.

3.4 PIPING CONNECTIONS

- A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for hydronic piping. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties" for steam and condensate piping. Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Where installing piping adjacent to chiller, allow space for service and maintenance.
- D. Generator Steam Piping Connections:
 - 1. Connect steam piping with trapped drip leg, gate valve, strainer, control valve, and pressure gauge. Install pressure reducing valve and safety relief valve upstream from steam-control valve to protect control valve from excessive steam pressure. Make connections to chiller with **[flange][or][union]**.
 - 2. Connect steam condensate piping with vacuum breaker, trapped drip leg, gate valve, strainer, float and thermostatic trap(s), **[condensate cooler],[condensate receiver],[condensate receiver and pump,]** and check valve. Make connections to chiller with **[flange][or][union]**.
- E. Generator Hot-Water Connections: Connect to generator inlet with shutoff valve, **[strainer],[flexible connector,]** control valve, thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to generator outlet with shutoff valve, check valve, balancing valve, **[flexible connector,]** flow switch, thermometer, plugged tee with shutoff valve and pressure gauge, **[flow meter,]** and drain connection with valve. Make connections to chiller with a **[flange][or][mechanical coupling]**.
- F. Evaporator-Liquid Connections: Connect to evaporator inlet with shutoff valve, **[strainer],[flexible connector,]** thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to evaporator outlet with shutoff valve, balancing valve, **[flexible connector,]** flow switch, thermometer, plugged tee with shutoff valve and pressure gauge, **[flow meter,]** and drain connection with valve. Make connections to chiller with a **[flange][or][mechanical coupling]**.

- G. Absorber/Condenser-Liquid Connections: Connect to inlet with shutoff valve, **[strainer,][flexible connector,]** thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to outlet with shutoff valve, balancing valve, **[flexible connector,]** flow switch, thermometer, plugged tee with shutoff valve and pressure gauge, **[flow meter,]** and drain connection with valve. Make connections to chiller with a **[flange][or][mechanical coupling]**.
 - 1. If not factory furnished or installed, provide pipe connecting liquid connection of absorber discharge and condenser inlet.
- H. Refrigerant Pressure Relief Device Connections: Extend **[vent piping][separate vent piping for each chiller]** to outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.
- I. Extend **[purge vent piping][separate purge vent piping for each chiller]** to outdoors. Comply with ASHRAE 15.
- J. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.5 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished with chiller but not factory mounted.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between control devices.
- C. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.

2. Operate chiller for run-in period.
3. Verify that absorbent and refrigerant charge is sufficient and chiller has been leak tested.
4. Verify that pumps are installed and functional.
5. Verify that thermometers and gauges are installed.
6. Verify that refrigerant pressure relief device is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators including deflection during chiller startup and shutdown.
9. Verify and record performance of liquid flow and low-temperature interlocks for evaporator and condenser.
10. Verify and record performance of chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
12. **<Insert startup steps if any>.**

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].

D. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Absorption water chillers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.9 DEMONSTRATION

A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain chillers.[**Video record training sessions.**]

END OF SECTION 23 64 13 16



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 64 13 16	23 64 13 00	Direct-Fired Absorption Water Chillers



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 64 16 00 - CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Centrifugal water chillers.
2. Packaged refrigerant-recovery units.
3. Heat-exchanger, brush-cleaning system.

B. Related Requirements:

1. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components.
2. Section 284400 "Refrigerant Detection and Alarm" for refrigerant monitors, alarms, supplemental breathing apparatus, and ventilation equipment interlocks.

1.2 DEFINITIONS

- A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input, using consistent units for any given set of rating conditions.
- B. DDC: Direct digital control.
- C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
- D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated in accordance with the method defined by **AHRI 550/590 (AHRI 551/591)** and referenced to AHRI standard rating conditions.
- E. kVAR: Kilovolt-ampere reactive.
- F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated in accordance with the method defined by **AHRI 550/590 (AHRI 551/591)** and intended for operating conditions other than the AHRI standard rating conditions.
- G. SCCR: Short-circuit current rating.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. Performance at AHRI standard conditions and at conditions indicated.
3. Performance at AHRI standard unloading conditions.
4. Minimum evaporator flow rate.

5. Minimum condenser[**and heat-reclaim condenser**] flow rate.
6. Refrigerant capacity of chiller.
7. Oil capacity of chiller.
8. Fluid capacity of evaporator, condenser[, **and heat-reclaim condenser**].
9. Characteristics of safety relief valves.
10. Minimum entering condenser-fluid temperature.
11. Performance at varying capacities with constant design condenser-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in [5 deg F (3 deg C)]<Insert temperature> increments.
12. Force and moment capacity of each piping connection.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Sustainable Design Submittals:

1. Product data indicating compliance with ASHRAE/IES 90.1.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and elevations, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source Quality-Control Certifications: For chillers.

D. Field quality-control reports.

E. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.

B. Instructional Videos: Including those that are pre-recorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Tool Kit:

1. A tool kit specially designed by chiller manufacturer for use in servicing chiller(s) furnished.
2. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit." Text size must be at least **1 inch (25 mm)** high.
4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size must be at least **1/2 inch (13 mm)** high.

- B. Touchup Paint: **[32-oz. (1-L)]<Insert volume>** container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Ship chillers from the factory fully charged with refrigerant.

- B. Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.

- C. Ship each oil-lubricated chiller with a full charge of oil.

1. Ship oil **[factory installed in chiller][in containers separate from chiller]**.

- D. Package chiller for export shipping in totally enclosed **[bagging][crate][crate with bagging]**.

1.8 WARRANTY

- A. Manufacturer Warranty: **[Manufacturer agrees][Installer agrees][Manufacturer and Installer agree]** to repair or replace chillers that fail in materials or workmanship within specified warranty period.

- B. Special Warranty: **[Manufacturer agrees][Installer agrees][Manufacturer and Installer agree]** to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

- a. Complete chiller, including refrigerant and oil charge.
- b. Complete compressor and drive assembly, including refrigerant and oil charge.
- c. Refrigerant **[and oil]** charge.

- 1)
 - 1) Loss of refrigerant charge for any reason due to manufacturer product defect and product installation.

- d. Parts **[only][and labor]**.

2. Warranty Period: **[Two][Three][Four][Five][10]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain centrifugal chillers from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Centrifugal chillers are to withstand the effects of earthquake motions. See Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria,
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: [1.5][1.0].
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- B. Condenser-Fluid Temperature Performance:
 - 1. Startup Condenser-Fluid Temperature: Chiller is to be capable of starting with an entering condenser-fluid temperature of [60 deg F (16 deg C)][55 deg F (13 deg C)][40 deg F (4 deg C)]**<Insert temperature>** and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
 - 2. Minimum Operating Condenser-Fluid Temperature: Chiller is to be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of [65 deg F (18 deg C)][60 deg F (16 deg C)][55 deg F (13 deg C)].
 - 3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
- C. Site Altitude: Chiller is to be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
- D. ASHRAE Compliance:
 - 1. ASHRAE 15 for safety code for mechanical refrigeration.
 - 2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
 - 3. ASHRAE/IES 90.1.
- E. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, as applicable to chiller design. For chillers charged with R-513A, R-515B, or R-1234ze(E) refrigerant, include an ASME U-stamp and nameplate certifying compliance.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Comply with requirements of UL Standards & Engagement Inc., and include label by a qualified testing agency showing compliance.
- H. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system are to automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought online.
2. Refer to Drawings for equipment served by back-up power systems.
3. Provide means and methods required to satisfy requirement, even if not explicitly indicated.

I. Outdoor Installations:

1. Chiller must be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a [25]<Insert number>-year period, with minimal degradation due to exposure to outdoor ambient conditions.
2. Chillers are equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past [30]<Insert number>-year period.

2.3 CAPACITIES AND CHARACTERISTICS

A. Capacity: <Insert tons (kW)>.

B. Full-Load Efficiency:

1. COP: <Insert value>.
2. EER: <Insert value>.
3. Power Input/Cooling Output: <Insert kW/ton (kW/kW)>.
4. Comply with FEMP.

C. Part-Load Efficiency:

1. IPLV: <Insert value>.
2. NPLV: <Insert value>.
3. Comply with FEMP.

D. Evaporator:

1. Pressure Rating: <Insert psig (kPa)>.
2. Number of Passes: [One][Two][Three].
3. Fluid Type: [Water]<Insert fluid type>.
4. Design Fluid Flow Rate: <Insert gpm (L/s)>.
5. Minimum Fluid Flow Rate: <Insert gpm (L/s)>.
6. Entering-Fluid Temperature: <Insert deg F (deg C)>.
7. Leaving-Fluid Temperature: <Insert deg F (deg C)>.
8. Fluid-Pressure Drop: <Insert feet of head (kPa)>.
9. Fluid Velocity: <Insert fps (m/s)>.
10. Fouling Factor: [0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert value>.

E. Condenser:

1. Pressure Rating: <Insert psig (kPa)>.
2. Number of Passes: [One][Two][Three].
3. Fluid Type: [Water]<Insert fluid type>.

4. Design Fluid Flow Rate: **<Insert gpm (L/s)>**.
5. Minimum Fluid Flow Rate: **<Insert gpm (L/s)>**.
6. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
7. Leaving-Fluid Temperature: **<Insert deg F (deg C)>**.
8. Fluid-Pressure Drop: **<Insert feet of head (kPa)>**.
9. Fluid Velocity: **<Insert fps (m/s)>**.
10. Fouling Factor: **[0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)][0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W)]<Insert value>**.

F. Heat-Reclaim Condenser:

1. Pressure Rating: **<Insert psig (kPa)>**.
2. Number of Passes: **[One][Two][Three]**.
3. Fluid Type: **[Water]<Insert fluid type>**.
4. Design Fluid Flow Rate: **<Insert gpm (L/s)>**.
5. Minimum Fluid Flow Rate: **<Insert gpm (L/s)>**.
6. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
7. Leaving-Fluid Temperature: **<Insert deg F (deg C)>**.
8. Fluid-Pressure Drop: **<Insert feet of head (kPa)>**.
9. Fluid Velocity: **<Insert fps (m/s)>**.
10. Fouling Factor: **[0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert value>**.

G. Compressor:

1. Number of Compressors: **[One][Two]<Insert number>**.
2. **[First]** Compressor Rated-Load Amperes: **<Insert number> A**.
3. **[First]** Compressor Locked-Rotor Amperes: **<Insert number> A**.
4. Second Compressor Rated-Load Amperes: **<Insert number> A**.
5. Second Compressor Locked-Rotor Amperes: **<Insert number> A**.

H. Chiller Control Electrical Requirements:

1. Power Connections: **[Integral][Field]**.
2. Power Input: **<Insert number> kW**.
3. Minimum Circuit Ampacity: **<Insert number> A**.
4. Maximum Overcurrent Protection Device: **<Insert number> A**.
5. Volts: **[120]<Insert number> V ac**.
6. Phase: **[Single][Three]**.
7. Hertz: 60.

I. Chiller Electrical Requirements:

1. Power Input: **<Insert number> kW**.
2. Power Factor: **[0.90][0.95]<Insert value>**.
3. Minimum Circuit Ampacity: **<Insert number> A**.
4. Maximum Overcurrent Protection Device: **<Insert number> A**.
5. Volts: **[208][240][480][600][2300][4160]<Insert number> V ac**.
6. Phase: Three.
7. Hertz: 60.

- J. Noise Rating: **[85]<Insert number> dBA** sound power level when measured in accordance with AHRI 575. Provide factory-installed sound treatment if necessary to achieve performance indicated.

2.4 CENTRIFUGAL WATER CHILLERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Carrier Global Corporation]**
 2. **[Daikin Applied]**
 3. **[Trane]**
 4. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Carrier Global Corporation]**
 2. **[Daikin Applied]**
 3. **[Trane]**
 4. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 5. **<Insert manufacturer's name>**
- C. Description: Factory-assembled and -tested chiller complete with compressor, compressor motor, compressor motor controller, **[lubrication system]** evaporator, condenser, **[heat-reclaim condenser as indicated,]** controls, interconnecting unit piping and wiring, and indicated accessories.
1. Multi-Piece Assembly: Disassemble chiller into major assemblies as required by the installation after factory testing **[and before packaging for shipment]**.
 2. Dual-Compressor Chillers: For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor-drive assembly fails.
- D. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.
- E. Compressor-Drive Assembly: Single-stage or multistage, variable- or dynamic-displacement, centrifugal-type compressor driven by an electric motor.
1. Oil-Free Technology:
 - a. **[Where indicated, compressors][Compressors]** must have oil-free technology.
 - b. **[Where indicated, compressors][Compressors]** must have oil-free technology using a permanent magnet synchronous motor, magnetic bearings, integral variable-frequency controller, and digital electronic controls.
 - 1) Magnetic Bearings or Roller Element Bearings:
 - a) Levitated shaft position is to be actively controlled and monitored by an X-, Y-, and Z-axis digital position sensor.
 - b) Compressor assembly is to be capable of coming to a controlled, safe stop without damage during a power failure by diverting stored power to the magnetic bearing control system.
 - 2) Integrate monitoring and controls associated with magnetic bearings into chiller controls, including following:
 - a) Operating Information: Positions, currents, temperatures, rotor elongation,

- and speed.
 - b) Warning Messages: Vibration.
 - c) Safety Shutdown: Internal fault, high bearing temperature or current, startup failure, speed signal fault, overspeed fault, communication error, rotor elongation, oscillator fault, rotor contraction, unauthorized rotation, and high and low voltage.
 - d) Cycling Shutdown: Position, low-frequency displacement, vibration, speed signal fault, startup failure, serial communications fault.
2. Compressor:
- a. Casing: Cast iron, precision ground.
 - b. Impeller: High-strength cast-aluminum or cast-aluminum alloy on carbon- or alloy-steel shaft.
3. Drive: **[Direct-drive, hermetic][Gear-drive, hermetic][Gear-drive, open][Direct- or gear-drive, hermetic][Direct- or gear-drive, open or hermetic]** design, using an electric motor as the driver.
- a. Gear Drives:
 - 1) For chillers with oil-lubricated gear drives, provide single- or double-helical gear design continuously coated with oil while chiller is operating.
 - 2) For chillers with oil-free technology, gear drives are to be of single- or double-helical gear design without the need for oil while chiller is operating, starting, and stopping.
 - 3) Gears must comply with American Gear Manufacturer Association standards.
 - b. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
 - c. Seals: Seal drive assembly to prevent refrigerant leakage.
4. Compressor Motor:
- a. Continuous-duty, squirrel-cage, induction-type, two-pole motor with energy efficiency required to suit chiller energy efficiency indicated.
 - b. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
 - c. Motor is to be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
 - d. For chillers with open drives, provide motor with **[open-dripproof][weather-protected, Type I][weather-protected, Type II][totally enclosed]** enclosure.
 - e. Provide motor with thermistor or RTD in **[single motor winding][each of three-phase motor windings]** to monitor temperature and report information to chiller control panel.
 - f. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
 - g. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.
5. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
- a. Overspeed Test: At least **[20][25]** percent above design operating speed.
 - b. Vibration Limits: Velocities not to exceed **0.15 inch/s (3.8 mm/s)** and **0.8 mil (0.02 mm)** peak to peak on all axes.
6. Service: Easily accessible for inspection and service.

- a. Compressor's internal components are to be accessible without having to remove compressor-drive assembly from chiller.
 - b. Provide lifting lugs or eyebolts attached to casing.
 7. Economizers: For multistage chillers, provide interstage economizers.
 8. Capacity Control: Modulating, variable-inlet, guide-vane assembly combined with hot-gas bypass, if necessary, to achieve performance indicated.
 - a. Maintain stable operation that is free of surge, cavitation, and vibration throughout range of operation. Configure to achieve most energy-efficient operation possible.
 - b. Operating Range: From 100 to **[15][10][5][zero]<Insert number>** percent of design capacity.
 - c. Condenser-Fluid Unloading Requirements over Operating Range: **[Constant-design of entering condenser-fluid temperature][Drop-in entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) for each 10 percent in capacity reduction]<Insert conditions>**.
 - d. Chillers with variable-frequency controllers must modulate compressor speed with variable-inlet, guide-vane control to achieve optimum energy efficiency.
 - e. Avoid use of hot-gas bypass if other options are available to achieve performance indicated. Apply hot-gas bypass in accordance with ASHRAE/IES 90.1 and governing codes.
 9. Oil Lubrication System: Consisting of pump, filtration, **[heater,]** cooler, factory-wired power connection, and controls.
 - a. Bearings, gears, and other rotating surfaces are to be lubricated at all operating, startup, coast down, and standby conditions, including power failure.
 - b. **[Manufacturer's standard method][Thermostatically controlled oil heater properly sized]** to remove refrigerant from oil.
 - c. **[Oil filter][Dual oil filters, one redundant,]** to be the easily replaceable cartridge type, minimum **[0.3][0.5]**-micron efficiency, with means of positive isolation while servicing.
 - d. **[Refrigerant][Water][Refrigerant- or water]-**cooled oil cooler.
 - e. Factory-installed and pressure-tested piping with isolation valves and accessories.
 - f. Oil compatible with refrigerant and chiller components.
 - g. Positive visual indication of oil level.
- F. Refrigeration:
1. Refrigerant:
 - a. Type: **[R-513A; ASHRAE 34, Class A1][R-514A; ASHRAE 34, Class B1][R-515B; ASHRAE 34, Class A1][R-1233zd(E); ASHRAE 34, Class A1][R-1234ze(E); ASHRAE 34, Class A2L]**.
 - b. Compatibility: Chiller parts exposed to refrigerants are to be fully compatible with refrigerants, and pressure components are to be rated for refrigerant pressures.
 2. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.
 3. Pressure Relief Device:
 - a. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
 - b. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
 - c. Where dual pressure relief devices are installed in series, provide a sensor with indicator between devices to indicate refrigerant release past first device.

- d. For Chillers Using R-514A or R-1233zd(E): **[Manufacturer's standard offering complying with ASHRAE 15 and ASHRAE 147][Rupture disc constructed of frangible carbon][or][spring-loaded, pressure relief valve; single- or multiple-reseating type]**.
 - e. For Chillers Using R-513A, R-515B, or R-1234ze(E): ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Provide pressure relief valve(s) for each chiller heat exchanger. Provide condenser with dual valves, one being redundant and configured to allow either valve to be replaced without loss of refrigerant.
4. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.
 5. Refrigerant Isolation for Chillers Using R-513A, R-515B, or R-1234ze(E):
 - a. Factory install **[positive shutoff, manual]** isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell.
 - b. Suction side of compressor from evaporator is to have an isolation valve to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell.
 6. Purge System:
 - a. For chillers operating at subatmospheric pressures **[using R-514A or R-1233zd(E) refrigerant]**, factory install an automatic purge system for collection and return of refrigerant and lubricating oil and for removal of noncondensables, including, but not limited to, water, water vapor, and noncondensable gases.
 - b. System is to be of thermal purge design, refrigerant or air cooled, and equipped with a carbon filter that includes an automatic regeneration cycle.
 - c. Factory wire to chiller's main power supply and system complete with controls, piping, and refrigerant valves to isolate the purge system from the chiller.
 - d. Construct components of noncorrodible materials.
 - e. Controls are to interface with chiller control panel to indicate modes of operation, set points, data reports, diagnostics, and alarms.
 - f. Efficiency of not more than **0.02 lb of refrigerant per pound of air (9 g of refrigerant per gram of air)** when rated in accordance with AHRI 580.
 - g. Operation independent of chiller in accordance with ASHRAE 147.
 7. Positive-Pressure System:
 - a. For chillers operating at subatmospheric pressures using **[R-514A][or][R-1233zd(E)]** refrigerant, factory install an automatic positive-pressure system.
 - b. During nonoperational periods, positive-pressure system is to automatically maintain a positive pressure for atmosphere in the refrigerant-pressure vessel of not less than **0.5 psig (3 kPa)** adjustable up to a pressure that remains within the vessel design pressure limits.
 - c. Provide factory-wired system including controller, electric heat, pressure transmitter, or switch.

G. Evaporator:

1. Description: Shell-and-tube design, with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent liquid refrigerant carryover from entering compressor.
4. Evaporator must have sight glass or other form of positive visual verification of liquid-refrigerant level.

5. Tubes:
 - a. Individually replaceable from either end and without damage to tube sheets and other tubes.
 - b. Mechanically expanded into end sheets and **physically attached to** intermediate tube sheets.
 - c. Material: **Copper****Copper-nickel alloy****Stainless steel****Titanium****Copper, copper-nickel alloy, stainless steel, or titanium**<Insert material>.
 - d. Nominal OD: **Manufacturer's choice****3/4 inch (19 mm)****1 inch (25 mm)****3/4 or 1 inch (19 or 25 mm)**].
 - e. Minimum Wall Thickness: **Manufacturer's choice****0.025 inch (0.6 mm)****0.028 inch (0.7 mm)****0.035 inch (0.9 mm)**<Insert value>.
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: **Enhanced****Smooth****Enhanced or smooth**].
6. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between fluid in tubes and refrigerant in shell.
7. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear, **but not more than 4 ft. (1.2 m) apart**].
8. Water Box:
 - a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. **Standard****Marine** type for water box with piping connections; standard type for water box without piping connections.
 - c. Provide water boxes **and marine water-box covers** with lifting lugs or eyebolts.
 - d. **Hinged****Davited****Hinged or davited** water boxes.
 - e. **Hinged****Davited****Hinged or davited** marine water-box covers.
 - f. Nozzle Pipe Connections: **Welded, ASME B16.5, flat-face flange****Welded, ASME B16.5, raised-face flange****Grooved for mechanical-joint coupling****Grooved with mechanical-joint coupling and flange adapter**].
 - g. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - h. Fit each water box with **3/4-inch (19-mm)****1-inch (25-mm)****3/4- or 1-inch (19- or 25-mm)**<Insert size> drain connection at low point and vent connection at high point, each with threaded plug.
9. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode, **zinc****or****magnesium**].
 - b. Coat wetted surfaces with a corrosion-resistant finish.
 - c. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
10. Flow Sensor: Thermal dispersion type, factory calibrated for Project-specific application.

H. Condenser:

1. Description: Shell-and-tube design, with water in tubes and refrigerant surrounding tubes within shell. Shell is to be separate from evaporator.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
4. Condenser is to have sight glass or other form of positive visual verification of refrigerant charge and condition.
5. Tubes:

- a. Individually replaceable from either end and without damage to tube sheets and other tubes.
 - b. Mechanically expanded into end sheets and **physically attached to** intermediate tube sheets.
 - c. Material: **Copper****Copper-nickel alloy****Stainless steel****Titanium****Copper, copper-nickel alloy, stainless steel, or titanium**<Insert material>.
 - d. Nominal OD: **Manufacturer's choice****3/4 inch (19 mm)****1 inch (25 mm)****3/4 or 1 inch (19 or 25 mm)**.
 - e. Minimum Wall Thickness: **Manufacturer's choice****0.025 inch (0.6 mm)****0.028 inch (0.7 mm)****0.035 inch (0.9 mm)**<Insert value>.
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: **Enhanced****Smooth****Enhanced or smooth**.
6. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between fluid in tubes and refrigerant in shell.
 7. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear, **but not more than 4 ft. (1.2 m) apart**.
 8. Water Box:
 - a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. **Standard****Marine** type for water box with piping connections. Standard type for water box without piping connections.
 - c. Water boxes **and marine water-box covers** are to have lifting lugs or eyebolts.
 - d. **Hinged****Davited****Hinged or davited** water boxes.
 - e. **Hinged****Davited****Hinged or davited** marine water-box covers.
 - f. Nozzle Pipe Connections: **Welded, ASME B16.5, flat-face flange****Welded, ASME B16.5, raised-face flange****Grooved for mechanical-joint coupling****Grooved with mechanical-joint coupling and flange adapter**.
 - g. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - h. Fit each water box with **3/4-inch (19-mm)****1-inch (25-mm)****3/4- or 1-inch (19- or 25-mm)**<Insert size> drain connection at low point and vent connection at high point, each with threaded plug.
 9. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode, **zinc****or****magnesium**.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
 - c. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
 10. Flow Sensor: Thermal dispersion type, factory calibrated for Project-specific application.
- I. Heat-Reclaim Condenser:
 1. Description: Shell-and-tube design, with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator and condenser.
 2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
 3. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
 4. Tubes:
 - a. Individually replaceable from either end and without damage to tube sheets and other tubes.

- b. Mechanically expanded into end sheets and **[physically attached to]** intermediate tube sheets.
 - c. Material: **[Copper][Copper-nickel alloy][Stainless steel][Titanium][Copper, copper-nickel alloy, stainless steel, or titanium]<Insert material>**.
 - d. Nominal OD: **[Manufacturer's choice][3/4 inch (19 mm)][1 inch (25 mm)][3/4 or 1 inch (19 or 25 mm)]**.
 - e. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert value>**.
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: **[Enhanced][Smooth][Enhanced or smooth]**.
5. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between fluid in tubes and refrigerant in shell.
6. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear, **[but not more than 4 ft. (1.2 m) apart]**.
7. Water Box:
 - a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. **[Standard][Marine]** type for water box with piping connections; standard type for water box without piping connections.
 - c. Water boxes **[and marine water-box covers]** are to have lifting lugs or eyebolts.
 - d. **[Hinged][Davited][Hinged or davited]** water boxes.
 - e. **[Hinged][Davited][Hinged or davited]** marine water-box covers.
 - f. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]**.
 - g. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - h. Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert size>** drain connection at low point and vent connection at high point, each with threaded plug.
8. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode, **[zinc][or][magnesium]**.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
 - c. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
9. Flow Sensor: Thermal dispersion type, factory calibrated for Project-specific application.
- J. Insulation:
 1. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C534, Type I for tubular materials and Type II for sheet materials.
 - a. Thickness: **[3/4 inch (19 mm)][1-1/2 inches (38 mm)]<Insert value>**.
 2. Adhesive: As recommended by insulation manufacturer.
 3. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components include, but are not limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
 - a. Apply adhesive to 100 percent of insulation contact surface.

- b. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
- c. Seal seams and joints to provide a vapor barrier.
- d. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
- e. Manufacturer has option to factory or field insulate chiller components installed in multiple pieces to reduce potential for damage during installation.
- f. Manufacturer has option to factory or field insulate water boxes and nozzles to reduce potential for damage during installation.

4. Field-Applied Insulation:

- a. Components that are not factory insulated are to be field insulated to comply with requirements indicated.
- b. Manufacturer must be responsible for chiller insulation whether factory or field installed, to ensure manufacturer is the single point of responsibility for chillers.
- c. Manufacturer factory-authorized service representative is to instruct and supervise installation of field-applied insulation.
- d. After field-applied insulation is complete, paint insulation to match factory-applied finish.

K. Electrical:

- 1. Factory installed and wired, and functionally tested at factory before shipment.
- 2. Single-point, field-power connection to **[fused disconnect switch][nonfused disconnect switch][circuit breaker]**. Minimum SCCR in accordance with UL 508 is to be as required by electrical power distribution system, but not less than **[42,000][65,000][100,000]<Insert value> A**.
 - a. Branch power circuit to each motor, electric heater, dedicated electrical load, and control, with **[circuit breaker][or][disconnect switch]** having SCCR to match main disconnecting means.
 - 1) NEMA KS 1, heavy-duty fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.
 - 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
 - b. NEMA ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable-frequency controller for each variable-speed motor furnished.
 - c. Control-circuit transformer with primary and secondary side fuses.
- 3. Terminal blocks with numbered **[and color-coded]** wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
- 4. Factory-installed wiring located outside of enclosures is to be installed in metal raceway. Provide terminal connections with not more than a **24-inch (610-mm)** length of **[liquidtight][flexible metallic][liquidtight or flexible metallic]** conduit.
- 5. Factory install and wire capacitor bank for the purpose of power factor correction to **[0.95]<Insert value> at [full load][all operating conditions]**.
 - a. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as that for motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
 - b. Capacitors are to be of non-PCB dielectric fluid, metallized electrode design, with low loss with low-temperature rise. Indicate kVAR ratings and do not exceed the maximum

- limitations set by NFPA 70. Provide individual cells as required.
 - c. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within one minute after de-energizing.
 - d. Provide a ground terminal and a terminal block or individual connectors for phase connection.
- L. Motor Controller:
 - 1. Enclosure: **[Factory installed, unit mounted][Factory furnished, field mounted]**, **[NEMA 250][NEMA ICS 6]**, **[Type 1][Type 4][Type 4X][Type 12]<Insert type>**, with hinged full-front access door **[with lock and key or padlock and key]**.
 - 2. Control Circuit: Obtained from **[integral control power transformer]<Insert source of control power>** with a control power **[transformer][source]** of enough capacity to operate connected control devices.
 - 3. Size overload relay in accordance with UL 1995 or provide as integral component of chiller control microprocessor.
 - 4. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.
 - 5. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.
 - 6. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.
 - 7. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
 - a. Include surge suppressor in solid-state power circuits to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 - b. Visual indication of motor and control status, including the following conditions:
 - 1) Controller on.
 - 2) Overload trip.
 - 3) Loss of phase.
 - 4) Starter fault.
 - 8. Accessories: Factory install devices in controller enclosure unless otherwise indicated.
 - a. Externally Operated[, **Door-Interlocked**] Disconnect: **[Fused disconnect switch][Nonfused disconnect switch][Circuit breaker]**. SCCR in accordance with UL 508 is to be as required by electrical power distribution system, but not less than **[42,000][65,000][100,000]<Insert value> A**.
 - b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
 - c. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
 - d. Control Relays: Time-delay relays.
 - e. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
 - f. Number-of-Starts Counter: Numerical readout on face of enclosure.
 - g. Meters: Panel type, **[2-1/2 inches (64 mm)][4-1/4 inches (108 mm)]** with **[90][120][270]-degree scale and [1][2] percent accuracy**. Where indicated, provide transfer device with an off position. Meters indicate the following:
 - 1) Ammeter: Output current for each phase, with current sensors rated to suit application.
 - 2) Voltmeter: Output voltage for each phase.
 - 3) Frequency Meter: Output frequency.
 - 4) Real-time clock with current time and date.
 - 5) Total run time.

6) <Insert features>.

h. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1) Selectable, digital display of the following:

- a) Phase Currents, Each Phase: Plus or minus 1 percent.
- b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
- c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
- d) Three-Phase Real Power: Plus or minus 2 percent.
- e) Three-Phase Reactive Power: Plus or minus 2 percent.
- f) Power Factor: Plus or minus 2 percent.
- g) Frequency: Plus or minus 0.5 percent.
- h) Integrated Demand with Demand Interval Selectable from Five to 60 Minutes: Plus or minus 2 percent.
- i) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

2) Mounting: Display and control unit flush or semirecessed in instrument compartment door.

- i. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
- j. Power Protection: Chiller must shut down within six cycles of power interruption.

M. Variable-Frequency Controller:

- 1. Motor controller is to be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
- 2. Description: NEMA ICS 2; listed and labeled in accordance with UL 508 as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
- 3. Enclosure: Unit mounted, NEMA 250, [Type 1][Type 4][Type 4x][Type 12], with hinged full-front access door with lock and key.
- 4. Integral Disconnecting Means: [Door-interlocked,] NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum SCCR in accordance with UL 508 is to be as required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
- 5. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors; suitable for variable torque loads.
- 6. Controller is to consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
 - a. Rectifier Section: Full-wave diode bridge that changes fixed-voltage, fixed-frequency, ac line power to a fixed dc voltage. Silicon controller rectifiers, current source inverters, and paralleling of devices are unacceptable. Rectifier is to be insensitive to phase rotation of the ac line.
 - b. Regulator: Full digital control of frequency and voltage.
 - c. Inverter Section: Change fixed dc voltage to variable-frequency, variable ac voltage for application to a squirrel-cage motor. Inverter is to produce a sine-coded, PWM output waveform and conduct no RFI back to the input power supply.
- 7. Output Rating: Three phase, with voltage proportional to frequency throughout voltage range.
- 8. Operating Requirements:
 - a. Input AC Voltage Tolerance: [460-V ac, plus 10 percent or 506 V maximum]<Insert

- voltage and tolerance>.**
- b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - c. Capable of driving full load, without derating, under the following conditions:
 - 1) Ambient Temperature: **[Zero]<Insert number> to [40][50]<Insert number> deg C.**
 - 2) Relative Humidity: Up to **[90][95]<Insert number> percent (noncondensing).**
 - 3) Altitude: Up to **[3300 ft. (1005 m)][6600 ft. (2010 m)]<Insert value>.**
 - d. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - e. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic filter; 98 percent with harmonic filter.
 - f. Overload Capability: 1.05 times the full-load current for seven seconds.
 - g. Starting Torque: As required by compressor-drive assembly.
 - h. Speed Regulation: Plus or minus 1 percent.
 - i. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
 - j. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller is to not operate continuously.
 - k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
9. Internal Adjustability Capabilities: Integral to controller or through chiller control panel.
- a. Minimum Output Frequency: 6 Hz.
 - b. Maximum Output Frequency: 60 Hz.
 - c. Acceleration: Two seconds to a minimum of 60 seconds.
 - d. Deceleration: Two seconds to a minimum of 60 seconds.
 - e. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.
10. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions must not result in component failure or the need for replacement:
- a. Overtemperature.
 - b. Short circuit at controller output.
 - c. Ground fault at controller output. Variable-frequency controller is to be able to start a grounded motor.
 - d. Open circuit at controller output.
 - e. Input undervoltage.
 - f. Input overvoltage.
 - g. Loss of input phase.
 - h. Reverse phase.
 - i. AC line switching transients.
 - j. Instantaneous overload, line to line or line to ground.
 - k. Sustained overload exceeding 100 percent of controller-rated current.
 - l. Starting a rotating motor.
11. Motor Protection: Controller is to protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
12. Automatic Reset and Restart:
- a. Capable of **[three][five]<Insert number>** restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
 - b. Controller is to be capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
13. Visual Indication: On face of controller enclosure or chiller control enclosure, indicating the

following conditions:

- a. Power on.
- b. Run.
- c. Overvoltage.
- d. Line fault.
- e. Overcurrent.
- f. External fault.
- g. Motor speed (percent).
- h. Fault or alarm status (code).
- i. DC-link voltage.
- j. Motor output voltage.
- k. Input kilovolt amperes.
- l. Total power factor.
- m. Input kilowatts.
- n. Input kilowatt-hours.
- o. Three-phase input voltage.
- p. Three-phase output voltage.
- q. Three-phase input current.
- r. Three-phase output current.
- s. Three-phase input voltage THD.
- t. Three-phase input current THD.
- u. Output frequency (Hertz).
- v. Elapsed operating time (hours).
- w. Diagnostic and service parameters.

14. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.

15. Control Signal Interface:

- a. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
- b. Manufacturer has option to incorporate control signal interface into chiller control panel.

16. Active Harmonic Distortion Filter:

- a. Factory mounted and wired to limit total voltage and current distortion to [5]<Insert number> percent.
- b. Factory mounted and wired to limit total demand distortion (TDD) to [5]<Insert number> percent of unit input.

17. Input Line Conditioning: <Insert requirements>.

18. Cooling: [Air][Refrigerant][Water][Air, refrigerant, or water] cooled.

N. Accessory Control Relays:

1. Control Relays: Auxiliary and adjustable time-delay relays.
2. Devices are to be factory installed in controller enclosure unless otherwise indicated.

O. Chiller Capacity Control Interface: Equip chiller with adaptive control logic to automatically adjust the compressor motor speed and the compressor pre-rotation inlet vane position independently to achieve maximum part-load efficiency in response to sensor inputs that are integral to the chiller controls.

P. Controls:

1. Description: Standalone and microprocessor based, with all memory stored in nonvolatile memory, so that reprogramming is not required on loss of electrical power.
2. Enclosure: Unit mounted, NEMA 250, [Type 1][Type 4][Type 4x][Type 12]<Insert type>, hinged or lockable, factory wired with a single-point, with field-power connection and a separate control circuit.
3. House factory-installed wiring outside of enclosures in a NFPA 70-approved raceway.[**Make terminal connections with liquidtight or flexible metallic conduit.**]
4. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:
 - a. Date and time.
 - b. Operating or alarm status.
 - c. Fault history with not less than last 10 faults displayed.
 - d. Set points of controllable parameters.
 - e. Trend data.
 - f. Operating hours.
 - g. Number of chiller starts.
 - h. Outdoor-air temperature or space temperature if required for chilled-water reset.
 - i. Entering- and leaving-fluid temperatures of evaporator and condenser.
 - j. Difference in fluid temperatures of evaporator and condenser.
 - k. Fluid flow of evaporator and condenser.
 - l. Fluid-pressure drop of evaporator and condenser.
 - m. Refrigerant pressures in evaporator and condenser.
 - n. Refrigerant saturation temperature in evaporator and condenser shell.
 - o. Compressor refrigerant suction and discharge temperature.
 - p. Compressor bearing temperature.
 - q. Motor bearing temperature.
 - r. Motor winding temperature.
 - s. Oil temperature.
 - t. Oil discharge pressure.
 - u. Phase current.
 - v. Percentage of motor-rated load amperage.
 - w. Phase voltage.
 - x. Demand power (kilowatts).
 - y. Energy use (kilowatt-hours).
 - z. Power factor.
 - aa. For chillers equipped with variable-frequency controllers and harmonic filters, include the following:
 - bb. Output voltage and frequency.
 - cc. Voltage THD for each phase.
 - dd. Supply current TDD for each phase.
 - ee. Inlet vane position.
 - ff. Controller internal ambient temperature.
 - gg. Heatsink temperature.
 - hh. Purge suction temperature if purge system is provided.
 - ii. Purge elapsed time if purge system is provided.
 - jj. <Insert status display items>.
5. Control Functions:
 - a. Manual or automatic startup and shutdown time schedule.
 - b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator-fluid temperature is to be reset based on [return-water][outdoor-air][space] temperature.
 - c. Current limit and demand limit.

- d. Condenser-fluid temperature.
 - e. External chiller emergency stop.
 - f. Variable evaporator flow.
 - g. Thermal storage.
 - h. Heat reclaim.
 - i. **<Insert control functions>**.
6. Manually Reset Safety Controls: The following conditions are to shut down chiller and require manual reset:
- a. Low evaporator **[pressure][temperature][pressure or temperature]**; high condenser pressure.
 - b. Low evaporator-fluid temperature.
 - c. Low oil differential pressure.
 - d. High or low oil pressure.
 - e. High oil temperature.
 - f. High compressor-discharge temperature.
 - g. Loss of condenser-fluid flow.
 - h. Loss of evaporator-fluid flow.
 - i. Motor overcurrent.
 - j. Motor overvoltage.
 - k. Motor undervoltage.
 - l. Motor phase reversal.
 - m. Motor phase failure.
 - n. Sensor- or detection-circuit fault.
 - o. Processor communication loss.
 - p. Motor controller fault.
 - q. Extended compressor surge.
 - r. Excessive air-leakage detection for chillers using R-514A or R-1233zd(E) refrigerant.
 - s. **<Insert manually reset safety controls>**.
7. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
8. Security Access: Provide electronic security access to controls through identification and password, with at least three levels of access: view only; view and operate; and view, operate, and service.
9. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
10. Communication Port: RS-232 port, USB 2.0 port or higher, or equivalent connection capable of connecting a printer **and a notebook computer**.
11. **[BAS][DDC System]** Interface: Factory install hardware and software to enable system to monitor, control, and display chiller status and alarms.
- a. Hardwired I/O Points:
 - 1) Monitoring: On-off status, **[common trouble alarm][electrical power demand (kilowatts)][electrical power consumption (kilowatt-hours)][power factor]<Insert monitoring point>**.
 - 2) Control: On-off operation, **[chilled-water, discharge temperature set-point adjustment][electrical power demand limit]<Insert control point>**.
 - b. Communication Interface: **[ASHRAE 135 (BACnet)][LonTalk][Modbus][Industry-accepted, open-protocol]<Insert type of interface>** communication interface is to enable control system operator to remotely control and monitor the chiller from an operator workstation.

- 1) Control features and monitoring points displayed locally at chiller control panel are to be available through the control system, including, at a minimum, the following:
 - a) Start-stop command from remote source.
 - b) Unit control source, local, analog, digital or modem.
 - c) Chiller control panel start-stop.
 - d) Accumulated operating hours.
 - e) Accumulated starts.
 - f) Compressor motor status.
 - g) Unit operation code.
 - h) Unit safety fault code.
 - i) Unit cycling fault code.
 - j) Chilled-water pump status.
 - k) Chilled-water flow proof.
 - l) Chilled-water entering temperature.
 - m) Chilled-water leaving temperature.
 - n) Chilled-water leaving temperature set-point adjustment from remote source.
 - o) Condenser(s) water entering temperature.
 - p) Condenser(s) water leaving temperature.
 - q) Evaporator refrigerant pressure.
 - r) Condenser(s) refrigerant pressure.
 - s) Evaporator refrigerant saturation temperature.
 - t) Condenser(s) refrigerant saturation temperature.
 - u) Refrigerant discharge temperature.
 - v) Refrigerant level.
 - w) Refrigerant liquid level set point.
 - x) Oil pressure differential.
 - y) Oil sump pressure.
 - z) Oil pump pressure.
 - aa) Oil sump temperature.
 - bb) High-speed thrust bearing proximity position.
 - cc) High-speed thrust bearing proximity reference.
 - dd) Motor current percent of full-load amps.
 - ee) Motor current Phase A.
 - ff) Motor current Phase B.
 - gg) Motor current Phase C.
 - hh) Motor current set-point adjustment from remote source.
 - ii) Motor bearing shaft end vibration.
 - jj) Motor bearing opposite shaft end vibration.
 - kk) Motor bearing shaft end temperature.
 - ll) Motor bearing opposite shaft end temperature.
 - mm) Motor average winding temperature.
 - nn) Variable-frequency controller selection, auto or fixed.
 - oo) Variable-frequency controller output voltage.
 - pp) Variable-frequency controller input power, rate.
 - qq) Variable-frequency controller input power, consumption.
 - rr) Variable-frequency controller DC bus voltage.
 - ss) Variable-frequency controller inverter link current.
 - tt) Variable-frequency controller output frequency.
 - uu) Variable-frequency controller internal ambient temperature.
 - vv) Variable-frequency controller converter heatsink temperature.
 - ww) Variable-frequency controller harmonic filter installed, true or false.
 - xx) Harmonic Filter THD at maximum voltage, percent.
 - yy) Harmonic filter total demand distortion at maximum current, percent.
 - zz) Harmonic filter total supply kVA.
 - aaa) Anti-recycle time remaining.

- bbb) Liquid line solenoid.
- ccc) Pre-rotation vanes position.
- ddd) Adaptive capacity control valve surge map installed, true or false.
- eee) Adaptive capacity control new surge point, true or false.
- fff) Adaptive capacity control surge type, pressure differential or current.
- ggg) Adaptive capacity control surge count.
- hhh) Adaptive capacity control PRV position.
- iii) Adaptive capacity control output frequency.
- jjj) **<Insert point>**.

12. Quick-Start Feature:

- a. Automatically restore chiller operation up to **[100]<Insert number>** percent capacity within **[three][five]<Insert number>** minutes after a **[15]<Insert number>** -second power interruption.
- b. Quick-start feature is to ensure guide vanes remain open following a power interruption event and quick ramp-up speed logic is employed to facilitate shortest time to deliver chilled water at set-point temperature.
- c. Chiller manufacturer is to provide integral UPS unit(s) with chiller controls if required to keep chiller integral controls operational to comply with requirement.
- d. Chiller manufacturer is to demonstrate chiller start time with the quick-start feature enabled while simulating power fault, power service return, restart time, and capacity control, to produce desired chilled-water temperature at load indicated.

Q. Finish:

- 1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
 - a. Provide at least one coat of primer with a total dry film thickness of at least **[1.5 mils (0.03 mm)][2 mils (0.05 mm)]<Insert thickness>**.
 - b. Provide at least **[one coat][two coats]** of **[alkyd-modified, vinyl enamel][epoxy][polyurethane]** finish with a total dry film thickness of at least **[2 mils (0.05 mm)][3 mils (0.08 mm)][4 mils (0.1 mm)]<Insert thickness>**.
 - c. Paint surfaces that are to be insulated before applying the insulation.
 - d. Paint installed insulation to match adjacent uninsulated surfaces.
 - e. Color of finish coat is to be **[manufacturer's standard][custom color selected by Architect]<Insert color description>**.

R. Accessories:

1. Flow Switches:

- a. Chiller manufacturer is to furnish a switch for each evaporator and **[condenser][heat-reclaim condenser]** and verify field-mounting location before installation.
- b. Paddle Flow Switches:
 - 1) Vane operated to actuate a double-pole, double-throw switch, with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
 - 2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
 - 3) Pressure rating equal to pressure rating of heat exchanger.
 - 4) Construct body and wetted parts of Type 316 stainless steel.
 - 5) House switch in a NEMA 250, **[Type 4]<Insert type>** enclosure constructed of die-

- cast aluminum.
 - 6) Vane length to suit installation.
 - c. Pressure-Differential Switches:
 - 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
 - 2) Performance: Switch is to withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
 - 3) Set Point: Screw type, field adjustable.
 - 4) Electrical Connections: Internally mounted screw-type terminal blocks.
 - 5) Switch Enclosure: NEMA 250, [Type 4]<Insert type>.
 - 6) Switch Action: Double-pole, double-throw switch, with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
2. Vibration Isolation:
 - a. Chiller manufacturer is to furnish vibration isolation for each chiller.
 - b. Neoprene Pad:
 - 1) Two layers of **0.375-inch- (10-mm-)** thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gauge, stainless steel plate.
 - 2) Fabricate pads from 40- to [50][60]<Insert number>-durometer neoprene.
 - 3) Provide stainless steel square bearing plate to load the pad uniformly between **20 and 40 psig (138 and 276 kPa)** with a **0.12- to 0.16-inch (3- to 4-mm)** deflection.
 - c. Spring Isolator:
 - 1) Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions.
 - 2) Design isolators so that the Kx/Ky ratio will be 1.0 or more for stability.
 - 3) Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Provide aluminum components that are etched and painted. Provide nuts, bolts, and washers that are zinc electroplated.
 - 4) Isolators are to be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate.
 - 5) An elastomeric pad with a minimum thickness of **0.25 inch (6 mm)** is to be bonded to the baseplate.
 - 6) Spring assembly is to be removable and fit within a welded-steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation.
 - 7) Isolated restraining bolts are to not be engaged during normal operation and are to connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.
 - 8) Select isolators for a nominal [1-inch (25-mm)][2-inch (50-mm)]<Insert dimension> deflection.
 - 9) Integrate seismic restraints in applications that require seismic requirements.
3. Sound Barrier:
 - a. Provide sound barrier only if required to comply with sound requirements indicated.
 - b. Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
 - c. Provide for repeated installation and removal without use of tape or caulk.
 - d. Inner and outer cover is to consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic

- barrier.
- e. Covers are to be double sewn and lock stitched, with edges folded and sewn so no raw cut edges are exposed.
- f. Form covers around control devices, gauges, conduit, piping, and supports without degrading sound-barrier performance.
- g. Continuously lap all exposed seams at least **2 inches (50 mm)** for better sound containment.
- h. Permanently label each section of cover to indicate its location, description, size, and number sequence.
- i. Randomly place stainless steel quilting pins to prevent covers from shifting and sagging.

2.5 PACKAGED REFRIGERANT-RECOVERY UNITS

- A. Description: Packaged portable unit, furnished by chiller manufacturer, consisting of compressor, air- or water-cooled condenser, recovery system, tank pressure gauges, filter dryer, and valving that allows for switching between liquid- and vapor-recovery mode.
- B. Refrigerant-recovery unit is to be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest chiller furnished.
- C. Provide units with lockable casters that permit rolling unit into position before locking position in place.
- D. Review chiller layout and provide refrigerant hoses of sufficient length to permit positioning of unit near chiller without compromising service access and safety.
- E. On water-cooled units, provide water hoses of sufficient length and pressure rating to permit positioning unit near chiller while connecting to closest field water source.
- F. Terminate hoses with quick-connect fittings and mating adapters.
- G. Provide unit power cord terminated with NEMA-rated plug suitable for unit power requirements.
 - 1. Quantity of mating receptacle(s) as required by application. **[Refer to Drawings for requirements]<Insert requirements>**.
 - 2. Power cord to be of sufficient length and rating to permit positioning unit near chiller while connecting to closest field power source. Power cord is not to be less than **<Insert length>** long.

2.6 HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM

- A. Description: Factory provided by chiller manufacturer, field-installed, brush-cleaning system on each chiller **[condenser]<Insert heat exchanger>** for tube cleaning and improved heat transfer.
- B. System is to prevent tube fouling at or below design conditions without interrupting normal equipment operation.
- C. System is to consist of a brush inserted into each tube and a catch basket attached to each end of the tube. A four-way valve is to operate to reverse the direction of water flow, to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator is to be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle is to be set up to match Project requirements.
- D. Components:

1. Brush: Each brush is to have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube is not to exceed **0.025 inch (0.6 mm)**.
2. Basket: Single-piece polypropylene basket with neck OD to press fit ID of tube. Design is to provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
3. Four-Way Valve:
 - a. Construct valve body of carbon steel, with internal sealing parts of hard rubber and Type 304 stainless steel.
 - b. Configure valve with parallel flow connections to minimize field installation of piping.
 - c. Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to that of condenser.
 - d. Provide flanged pipe connections.
 - e. Valve manufacturer is to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operating conditions of maximum differential pressure.
 - f. Hydrostatically test to 1.5 times the design working pressure.
 - g. Design the valve to cause no more than **0.5-psig (3-kPa)** pressure drop at design flow conditions.
 - h. Provide valve with valve-mounted indicating/warning light that will light before the valve begins rotation.
 - i. Valve Actuator, Electric: Mount electric actuator to operate valve.
 - j. Valve Actuator, Pneumatic: Mount pneumatic piston-type actuator to operate valve. Actuator is to be suitable for operation using field-supplied air pressure.
 - k. Position Switches: Factory mount microswitches on the valve to indicate the complete turn of valve in both normal and reverse flow.
4. Control Panel: Factory or field mount a control panel on chiller. Control panel is to include the following features:
 - a. NEMA 250, **[Type 1][Type 4][Type 4x][Type 12]** enclosure.
 - b. Timer to automatically initiate the cleaning cycle over a 24-hour period.
 - c. Manual override of preset cleaning cycle.
 - d. Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction," indicating a slow turn or incomplete valve turn.
 - e. For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
 - f. Flow switch bypass.
 - g. Unloading signal to chiller.

2.7 SOURCE QUALITY CONTROL

- A. AHRI Certification: Certify chiller in accordance with "Water-Cooled Chiller Certification Program."
- B. Performance Tolerance: Comply with the following in lieu of **AHRI 550/590 (AHRI 551/591)**:
 1. Allowable Capacity Tolerance: **[Zero]<Insert number>** percent.
 2. Allowable Full-Load Energy Efficiency Tolerance: **[Zero]<Insert number>** percent.
 3. Allowable Part-Load Energy Efficiency Tolerance: **[Zero]<Insert number>** percent.
- C. Perform functional **[run]** tests of chillers before shipping.
- D. Factory Performance Testing:
 1. Factory performance test chillers, before shipping, in accordance with **AHRI 550/590 (AHRI 551/591)**.

2. Test the following conditions:
 - a. Design conditions indicated.
 - b. Reduction in capacity from design to minimum load in steps of [10][25][33]<Insert number> with condenser fluid at design conditions.
 - c. Reduction in capacity from design to minimum load in steps of [10][25][33]<Insert number> with varying entering condenser-fluid temperature from design to minimum conditions in [5 deg F (3 deg C)]<Insert temperature> increments.
 - d. At [one][two][three][four][five][10]<Insert number> point(s) of varying part-load performance to be selected by Owner at time of test.
3. Allow [Owner]<Insert entity> access to place where chillers are being tested. Notify Owner in writing at least [30]<Insert number> days in advance of testing.
4. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

E. Factory Sound Testing:

1. For chillers located indoors, rate sound power level in accordance with AHRI 575.
2. Factory sound test chillers, before shipping, in accordance with AHRI 575.
3. Test the following conditions:
 - a. Design conditions indicated.
 - b. Chiller operating at calculated worst-case sound condition.
 - c. At [one][two][three][four][five]<Insert number> point(s) of varying part-load performance to be selected by Owner at time of test.
4. Allow [Owner]<Insert entity> access to place where chillers are being tested. Notify Owner in writing at least [30]<Insert number> days in advance of testing.
5. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

F. Factory test and inspect evaporator [and condenser][, condenser, and heat-reclaim condenser] in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

G. Factory test and inspect evaporator [and condenser][, condenser and heat-reclaim condenser] in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test fluid side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Pressure proof test refrigerant side of heat exchangers to a minimum of **45 psig (310 kPa)**. Vacuum and pressure test for leaks.

H. Eddy Current Testing:

1. Perform factory testing of evaporator and condenser tubes of each chiller to ensure tube quality and longevity.
2. Submit test report, including, at a minimum:
 - a. List of equipment used and equipment settings.
 - b. Test data reports and accompanying strip charts of calibrations.
 - c. Identify tubes with significant defects and typical indications.
 - d. Statistical summary of defect indications.
 - e. Recommendations concerning tube condition, tube replacement, tube removal for evaluation, and future frequency of testing.
 - f. Approval by an American Society for Nondestructive Testing, Level III eddy current technician.

I. Owner Travel Expenses:

1. Include cost associated with Owner travel expenses to witness factory testing. Total value attributed to travel expenses is to be clearly indicated.
2. Expenses are to include roundtrip coach airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation, and all associated taxes and fees.
3. Exclude other incidental expenses not indicated.
4. Include travel expenses for [one][two]<Insert number> Owner representative(s) with origin of <Insert city, state, country>.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine chillers before installation. Reject chillers that are damaged.
- B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, control and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.
 1. Chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and control and electrical connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF CENTRIFUGAL WATER CHILLERS

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
- B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.
- C. Install chillers on support structure indicated.
- D. Equipment Mounting:
 1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Maintain manufacturer's recommended clearances for service and maintenance.
- F. Maintain clearances required by governing code.
- G. Chiller manufacturer's factory-trained service personnel are to charge chiller with refrigerant and fill with oil if not factory installed.
- H. Install separate devices furnished by manufacturer and not factory installed.

1. Chillers shipped in multiple major assemblies are to be field assembled by chiller manufacturer's factory-trained service personnel.

3.3 INSTALLATION OF PACKAGED REFRIGERANT-RECOVERY UNIT

- A. Install field electric power as required for unit furnished. Install power connections at multiple locations as recommended by chiller manufacturer for unit to service chillers indicated. Install receptacle(s) furnished with unit.
- B. Install field water source as required for unit furnished. Install connections at multiple locations as recommended by chiller manufacturer for unit to service chillers indicated. Terminate connections with valves.
- C. Install quick-connect adapters furnished with unit.
- D. Functionally test unit for proper operations with field connections to power and water, as applicable.

3.4 INSTALLATION OF HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM

- A. Install brush-cleaning system control panel adjacent to chiller control panel.
- B. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
- C. Install field electric power, as required, to each system control panel and electric actuated valve.
- D. Install pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
- E. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
- F. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

3.5 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping," Section 232116 "Hydronic Piping Specialties," and Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to chillers, allow space for service and maintenance.
- C. Evaporator-Fluid Connections:
 1. Connect to evaporator inlet with shutoff valve, **[strainer,][flexible connector,]** thermometer, and plugged tee with pressure gauge.
 2. Connect to evaporator outlet with shutoff valve, balancing valve, **[flexible connector,]** thermometer, plugged tee with shutoff valve and pressure gauge, **[flow meter,]** and drain connection with valve.

3. Make connections to chiller with a **[flange][mechanical coupling][flange or mechanical coupling]**.

D. Condenser-Fluid Connections:

1. Connect to condenser inlet with shutoff valve, **[strainer,][flexible connector,]** thermometer, and plugged tee with pressure gauge.
2. Connect to condenser outlet with shutoff valve, balancing valve, **[flexible connector,]** thermometer, plugged tee with shutoff valve and pressure gauge, **[flow meter,]** and drain connection with valve.
3. Make connections to chiller with a **[flange][mechanical coupling][flange or mechanical coupling]**.

E. Heat-Reclaim Condenser-Fluid Connections:

1. Connect to condenser inlet with shutoff valve, **[strainer,][flexible connector,]** thermometer, and plugged tee with pressure gauge.
2. Connect to condenser outlet with shutoff valve, balancing valve, **[flexible connector,]** thermometer, plugged tee with shutoff valve and pressure gauge, **[flow meter,]** and drain connection with valve.
3. Make connections to chiller with a **[flange][mechanical coupling][flange or mechanical coupling]**.

F. Refrigerant-Pressure Relief Device Connections:

1. For chillers installed indoors, extend **[vent piping][separate vent piping for each chiller]** to the outdoors without valves or restrictions.
2. Comply with ASHRAE 15.
3. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.

- G. For chillers equipped with a purge system, extend **[purge vent piping][separate purge vent piping for each chiller]** to the outdoors. Comply with ASHRAE 15 and ASHRAE 147.

- H. Connect each chiller drain connection with a drain valve, which is full size of drain connection. **[Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.]**

- I. Connect each chiller water box vent connection with an **[automatic][or][manual]** vent, which is full size of vent connection.

3.6 ELECTRICAL POWER CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection. Nameplate is to be laminated phenolic layers of black with engraved white letters at least **1/2 inch (13 mm)** high. Locate nameplate where easily visible.

3.7 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

- B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.
- C. Connect control wiring between chiller control interface and **[DDC control system]<Insert system description>** for remote monitoring and control of chillers. Comply with requirements in **[Section 230923 "Direct Digital Control (DDC) System for HVAC."]<Insert Section number and title.>**
- D. Install nameplate on face of chiller control panel indicating the control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate is to be laminated phenolic layers of black with engraved white letters at least **0.5 inch (12.7 mm)** high.

3.8 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
 - 3. Verify that pumps are installed and functional.
 - 4. Verify that thermometers and gauges are installed.
 - 5. Operate chiller for run-in period.
 - 6. Check bearing lubrication and oil levels.
 - 7. Verify that refrigerant pressure relief device is vented outside.
 - 8. Verify proper motor rotation.
 - 9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
 - 10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator[**and condenser**][, **condenser, and heat-reclaim condenser**].
 - 11. Verify and record performance of chiller protection devices.
 - 12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- B. Inspect field-assembled components, equipment installation, piping, controls and electrical connections for proper assembly, installation, and connection.
- C. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.
- D. Prepare test and inspection startup reports.

3.9 WARRANTY PERIOD TESTING

- A. Within **[one]<Insert number>** month(s) of warranty period expiration, perform testing, analysis, and reporting indicated for each chiller.
- B. Eddy Current Testing:
 - 1. Solicit services of a third-party testing agency, specializing in such analysis, to perform testing of evaporator and condenser tubes, to ensure tube quality and longevity.
 - 2. Submit test report to Owner, including, at a minimum:
 - a. List of equipment used and equipment settings.
 - b. Test data reports and accompanying strip charts of calibrations.
 - c. Identify tubes with significant defects and typical indications.

- d. Statistical summary of defect indications.
 - e. Recommendations concerning tube condition, tube replacement, tube removal for evaluation, and future frequency of testing.
 - f. Approval by an American Society for Nondestructive Testing, Level III eddy current technician.
- C. Oil Analysis:
 - 1. Take oil sample and solicit services of a third-party testing agency, specializing in such analysis, to perform oil analysis.
 - 2. Submit analysis results and recommendations to Owner.
- D. Refrigerant Analysis:
 - 1. Take refrigerant sample and solicit services of a third-party testing agency, specializing in such analysis, to perform refrigerant analysis.
 - 2. Submit analysis results and recommendations to Owner.
- E. Site Access and Scheduling:
 - 1. Contact Owner to schedule testing at least 30 days in advance of testing.
 - 2. Make mutually agreeable schedule adjustments to accommodate Owner's request for testing.
 - 3. Review, with Owner, requirements for visitors in advance of testing.
 - 4. Comply with Owner requirements for visitors while on-site.

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers. [**Video record the training sessions and provide electronic copy to Owner.**]
 - 1. Instructor must be factory trained and certified.
 - 2. Provide not less than [eight]<Insert number> hours of training.
 - 3. Provide not less than [16]<Insert number> hours of training spread across consecutive days, not to exceed [eight]<Insert number>hours per day.
 - 4. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
 - 5. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 - 6. Obtain Owner sign-off that training is complete.
 - 7. Owner training is to be held at Project site.

END OF SECTION 23 64 16 00



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 64 16 13	23 64 16 00	Centrifugal Water Chillers
23 64 16 16	23 64 16 00	Centrifugal Water Chillers
23 64 23 00	23 64 23 13	Air-Cooled, Scroll Water Chillers
23 64 23 00	23 64 23 16	Water-Cooled, Scroll Water Chillers



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 64 23 13 - AIR-COOLED, SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air-cooled, scroll water chillers.

1.2 DEFINITIONS

- A. BAS: Building automation system.
- B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- C. DDC: Direct digital control.
- D. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in Btu/h to the total power input given in watts at any given set of rating conditions.
- E. GFI: Ground fault interrupt.
- F. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated per the method defined by **AHRI 550/590 (AHRI 551/591)** and referenced to AHRI standard rating conditions.
- G. I/O: Input/output.
- H. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
- I. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by **AHRI 550/590 (AHRI 551/591)** and intended for operating conditions other than the AHRI standard rating conditions.
- J. SCCR: Short-circuit current rating.
- K. TEAO: Totally enclosed air over.
- L. TENV: Totally enclosed nonventilating.

1.3 ACTION SUBMITTALS

- A. Product Data: For each specified system and assembly, including components and accessories.
 1. Include refrigerant, rated capacities, operating characteristics, and furnished specialties and accessories.
 2. Performance at AHRI standard conditions and at conditions indicated.

3. Performance at AHRI standard unloading conditions.
4. Minimum evaporator flow rate.
5. Refrigerant capacity of water chiller.
6. Oil capacity of water chiller.
7. Fluid capacity of evaporator.
8. Characteristics of safety relief valves.
9. Force and moment capacity of each piping connection.

B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Diagrams for power, signal, and control wiring.

C. Delegated Design Submittals: For water chiller supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators [**and seismic restraints**] and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Restraint Details: [**Wind-**][**and**][**seismic-**] detail fabrication and attachment of [**wind and**] seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

D. Sustainable Design Submittals:

1. Product Data: For energy performance.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Certificates: For certification required in "Quality Assurance" Article.

C. Seismic Qualification Data: Certificates, for water chillers, accessories, and components, from manufacturers. Submit certification that specifies equipment will withstand wind forces identified in Section 018123 "Facility Seismic and Wind Criteria" and coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Installation instructions.

- E. Source quality control reports.
- F. Startup service reports.
- G. Sample Warranty: For specified special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each water chiller.
- B. Spare Parts List: Recommended spare parts list with quantity for each.
- C. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.
- D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Tool kit to include the following:
 - 1. A tool kit specially designed by chiller manufacturer for use in servicing chiller(s) furnished.
 - 2. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
 - 3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit" with text size at least **1 inch (25 mm)** high.
 - 4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size is to be at least **1/2 inch (13 mm)** high.
- B. Touchup Paint: **[32 oz. (1 L)]<Insert volume>** container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.7 QUALITY ASSURANCE

- A. AHRI Certification: Certify chiller in accordance with AHRI 590 certification program.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.
- B. Package water chiller for export shipping.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.
 - 1. Extended warranties include, but are not limited to, the following:
 - a. Complete chiller including refrigerant and oil charge.



- b. Complete compressor and drive assembly including refrigerant and oil charge.
 - c. Refrigerant [**and oil**] charge.
 - 1) Loss of refrigerant charge for any reason due to manufacturer's product defect and product installation.
 - d. Parts [**only**][**and labor**] .
2. Warranty Period: [**Five**]**<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for chillers, including comprehensive engineering analysis.
- B. Wind-Restraint Performance:
 - 1. See Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for building classification criteria.
- C. Seismic Performance: Scroll water chillers to withstand the effects of earthquake motions. See Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified [**and the unit will be fully operational after the seismic event**] ."
 - 2. Component Importance Factor: [**1.5**][**1.0**] .
 - 3. Component Amplification Factor: **<Insert value>** .
 - 4. Component Response Modification Factor: **<Insert value>** .
- D. Site Altitude: Chiller is to be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
- G. Comply with NFPA 70.
- H. Comply with requirements of UL 1995, "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.

2.2 AIR-COOLED, SCROLL WATER CHILLERS

- A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide**

products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :

1. [Carrier Global Corporation]
 2. [Daikin Applied]
 3. [Trane]
 4. [WaterFurnace International, Inc.]
 5. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 6. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Carrier Global Corporation]
 2. [Daikin Applied]
 3. [Trane]
 4. [WaterFurnace International, Inc.]
 5. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 6. <Insert manufacturer's name>
- C. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, air-cooled condenser with fans, electrical power, controls, and indicated accessories.
- D. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.
- E. Sound-reduction package is to have the following:
1. Acoustic enclosure around compressors.
 2. Reduced-speed fans with acoustic treatment.
 3. Designed to reduce sound level without affecting performance.
- F. Security Package: Security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles are to be coated for corrosion resistance and are to be removable for service access.
- G. Cabinet:
1. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
 2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
 3. Casing: Galvanized steel.
 4. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a [500]<Insert time> -hour salt-spray test in accordance with ASTM B117.
- H. Compressor-Drive Assemblies:
1. Compressors:
 - a. Description: Positive-displacement direct drive with hermetically sealed casing.
 - b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
 - 1) For multiple compressor assemblies, it is acceptable to isolate each compressor

assembly in lieu of each compressor.

- c. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
- d. Capacity Control: On-off compressor cycling [, **plus hot-gas bypass**] .
 - 1) Digital compressor unloading is an acceptable alternative to achieve capacity control.
- e. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge.
 - 1) Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.
- f. Vibration Isolation: Mount individual compressors on vibration isolators.
 - 1) For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.

2. Compressor Motors:

- a. Hermetically sealed and [**cooled by refrigerant suction gas**][or][**air-cooled**] .
- b. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

3. Compressor Motor Controllers:

- a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

I. Refrigeration System:

- 1. Refrigerant: [**R-32, ASHRAE 34 Safety Group A2L**][**R-454B, ASHRAE 34 Safety Group A2L**]**<Insert refrigerant type>** .
- 2. Refrigerant Compatibility: Parts exposed to refrigerants are to be fully compatible with refrigerants, and pressure components are to be rated for refrigerant pressures.
- 3. Refrigerant Circuit: Each circuit is to include [**an electronic**][or][**a thermal**] -expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
- 4. Refrigerant Isolation: Factory install positive shutoff isolation valves in compressor discharge line and refrigerant liquid-line to allow the isolation and storage of refrigerant charge in the chiller condenser.
 - a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in each circuit in lieu of each compressor.
- 5. Pressure Relief Device:
 - a. Comply with requirements in ASHRAE 15 [, **ASHRAE 147,**] and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
 - c. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) is to be provided for each heat exchanger.

J. Evaporator:

1. Brazed-plate or shell-and-tube design, as indicated on Drawings.
2. Shell and Tube:
 - a. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
 - b. Code Compliance: Tested and stamped in accordance with ASME Boiler and Pressure Vessel Code.
 - c. Shell Material: Carbon steel.
 - d. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
 - e. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping. [**Furnish flange adapters to mate to flanged piping.**]
 - f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
3. Brazed Plate:
 - a. Direct-expansion, single-pass, brazed-plate design.
 - b. Type **[304][or][316]** stainless steel construction.
 - c. Code Compliance: Tested in accordance with ASME Boiler and Pressure Vessel Code.
 - d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping. [**Furnish flange adapters to mate to flanged piping.**]
 - e. Inlet Strainer: Factory-furnished, **[20][or][40]<Insert value>** -mesh strainer for field installation in supply piping to evaporator. Manufacturer has option to factory install strainer.
4. Flow Switch: Factory-furnished **[and -installed,][thermal-type]** flow switch wired to chiller operating controls.
5. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to **[minus 20 deg F (minus 29 deg C)]<Insert temperature>** .
6. Remote-Mounting Kit: Designed for remote field mounting where indicated. Provide kit for field installation.

K. Air-Cooled Condenser:

1. Coil(s) with integral subcooling on each circuit.
2. Copper Tube with Plate Fin Coils:
 - a. Construct coils of copper tubes mechanically bonded to **[aluminum][copper]** fins.
 - b. Coating: **[None][Corrosion resistant]** .
3. Aluminum Microchannel Coils:
 - a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
 - b. Single- or multiple-pass arrangement.
 - c. Construct fins, tubes, and header manifolds of aluminum alloy treated with a corrosion-resistant coating.
4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
5. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.



6. Fan Motors: TENV or TEAO enclosure, with sealed and permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
 - a. Overcurrent- and thermal-overload protection not integral to motor is acceptable if provided with chiller electrical power package.
7. Fan Guards: Removable steel safety guards with corrosion-resistant [**PVC**] coating.

L. Heat Recovery Condenser:

1. Brazed plate, or shell and tube; as indicated, capable of [**full**][**partial**] heat recovery.
2. Shell and Tube:
 - a. Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.
 - b. Code Compliance: Tested and stamped in accordance with ASME Boiler and Pressure Vessel Code.
 - c. Shell Material: Carbon steel.
 - d. Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
 - e. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
 - f. Provide each condenser circuit with a pressure relief device, purge cock, and liquid-line shutoff valve.
 - g. Provide each condenser with water circuit vent and drain.
3. Brazed Plate:
 - a. Type 316 stainless steel construction.
 - b. Code Compliance: Tested in accordance with ASME Boiler and Pressure Vessel Code.
 - c. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
 - d. Inlet Strainer: Factory-furnished, [**20**][**or**][**40**]<Insert value> -mesh strainer for field installation in supply piping to condenser. Manufacturer has option to factory install strainer.
4. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the heat recovery condenser to [**minus 20 deg F (minus 29 deg C)**]<Insert temperature> .
5. Insulation: Insulation on heat recovery condenser is to match evaporator insulation.
6. Controls: Integral to chiller control package.

M. Chilled-Water Hydronic Package:

1. Factory-furnished [**and -installed**] hydronic package consisting of the following:
 - a. Pumps: Single or dual pumps with capacity, as indicated.
 - 1) [**Vertical in-line**]<Insert type> type, single-stage design, serviceable without disturbing piping connections.
 - 2) Cast-iron, ductile-iron, bronze, or stainless steel body.
 - 3) Bronze or stainless steel impeller keyed to shaft and secured with screw.
 - 4) Premium efficiency motor with TEFC motor enclosure.
 - 5) Dual pump packages to provide for servicing and replacement of failed pump with other pump operating.

- 6) Variable-speed pumps with variable-frequency controllers integral to pump motor or provided with chiller electrical package.
- b. Expansion Tank: [**Replaceable**] bladder type. [**Pre-charge tank to x psi (y kPa).**]
- c. Storage Tank: Insulated carbon-steel tank with [**internal baffles,**] drain and vent connections; with capacity indicated.
- d. Piping: [**Copper tube**][or][**carbon-steel pipe**] .
- e. Strainers: Y-type at suction side of each pump.
- f. Valves:
 - 1) Ball- or butterfly-style valves for isolation and balancing.
 - 2) Check valve on each pump discharge for dual pump packages.
 - 3) Drain valves to be positioned to drain isolated sections of pipe and equipment.
 - 4) Option to use combination valves.
- g. Hydronic Specialties:
 - 1) Air Vents: [**Automatic**][or][**manual**] air vents located and arranged to vent air from high points and locations capable of trapping air.
 - 2) Test Plugs: Located to measure pressure difference across each pump and strainer.
2. Hydronic package rated for same pressure as evaporator.
3. Pressure and leak tested before apply insulation.
4. Insulation on hydronic package is to match evaporator insulation.
5. Controls:
 - a. Lead/lag operation for dual pump packages.
 - b. Controlled to automatically equalize run time.
 - c. Control of variable-speed pumps.
 - d. Integral to chiller control package.
 - e. Remotely controlled through field interface with building controls.
6. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the chilled-water hydronic package to [**minus 20 deg F (minus 29 deg C)**]<Insert temperature> .

N. Insulation:

1. Closed-cell, flexible, elastomeric thermal insulation complying with ASTM C534/C534M, Type I for tubular materials and Type II for sheet materials.
 - a. Thickness: [**3/4 inch (19 mm)**][**1-1/2 inches (38 mm)**]<Insert dimension> .
2. Adhesive: As recommended by insulation manufacturer.
3. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components are to include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
 - a. Apply adhesive to 100 percent of insulation contact surface.
 - b. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
 - c. Seal seams and joints to provide a vapor barrier.
 - d. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
 - e. Manufacturer has option to factory or field insulate chiller components to reduce potential for damage during installation.

f. Field-Applied Insulation:

- 1) Components that are not factory insulated are to be field insulated to comply with requirements indicated.
- 2) Manufacturer is to be responsible for chiller insulation whether factory or field installed to ensure that manufacturer is the single point of responsibility for chillers.
- 3) Manufacturer's factory-authorized service representative is to instruct and supervise installation of field-applied insulation.
- 4) After field-applied insulation is complete, paint insulation to match factory-applied finish.

O. Electrical:

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary are to provide a single-point field power connection to water chiller.
3. House in a unit-mounted, ANSI/NEMA EN 10250, [Type 3R]<Insert type> enclosure with hinged access door with lock and key or padlock and key.
4. Wiring is to be numbered and color-coded to match wiring diagram.
5. Factory wiring is to be located outside of an enclosure in a [metal] raceway. Make terminal connections with not more than a 24-inch (610-mm) length of [liquidtight][or][flexible metallic] conduit.
6. Field power interface is to be to [wire lugs][NEMA BS 31047 heavy duty disconnect switch][circuit breaker] . Minimum SCCR in accordance with UL 508 to be as required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
7. Each motor is to have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:
 - a. NEMA BS 31047, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.
 - b. NEMA BS 31047, heavy-duty, nonfusible switch.
 - c. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
8. Each motor is to have overcurrent protection.
9. Overload relay sized in accordance with UL 1995, or an integral component of water chiller control microprocessor.
10. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
11. Power Factor Correction: Capacitors to correct power factor to [0.90][0.95]<Insert value> at full load.
12. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
13. Control Relays: Auxiliary and adjustable time-delay relays, or an integral to water chiller microprocessor.
14. Service Receptacle:
 - a. Unit-mounted, 120-V GFI duplex receptacle.
 - b. Power receptacle from chiller internal electrical power wiring.
15. Indicate the following for water chiller electrical power supply:
 - a. Current, phase to phase, for all three phases.
 - b. Voltage, phase to phase and phase to neutral for all three phases.
 - c. Three-phase real power (kilowatts).
 - d. Three-phase reactive power (kilovolt amperes reactive).

- e. Power factor.
 - f. Running log of total power versus time (kilowatt hours).
 - g. Fault log, with time and date of each.
16. Controls:
- a. Factory installed and wired, and functionally tested at factory before shipment.
 - b. Standalone, microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
 - c. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
 - d. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, digital display. Display the following:
 - 1) Date and time.
 - 2) Operating or alarm status.
 - 3) Operating hours.
 - 4) Outside-air temperature if required for chilled-water reset.
 - 5) Temperature and pressure of operating set points.
 - 6) Chilled-water entering and leaving temperatures.
 - 7) Refrigerant pressures in evaporator and condenser.
 - 8) Saturation temperature in evaporator and condenser.
 - 9) No cooling load condition.
 - 10) Elapsed time meter (compressor run status).
 - 11) Pump status.
 - 12) Antirecycling timer status.
 - 13) Percent of maximum motor amperage.
 - 14) Current-limit set point.
 - 15) Number of compressor starts.
 - 16) Alarm history with retention of operational data before unit shutdown.
 - 17) Superheat.
 - e. Control Functions:
 - 1) Manual or automatic startup and shutdown time schedule.
 - 2) Capacity control based on evaporator leaving-fluid temperature.
 - 3) Capacity control compensated by rate of change of evaporator entering-fluid temperature.
 - 4) Chilled-water entering and leaving temperatures, control set points, and motor load limit. Reset chilled-water leaving temperature based on **[return-water][outside-air][space]<Insert variable>** temperature.
 - 5) Current limit and demand limit.
 - 6) Condenser-water temperature.
 - 7) External water chiller emergency stop.
 - 8) Antirecycling timer.
 - 9) Automatic lead-lag switching.
17. Manual-Reset Safety Controls: The following conditions are to shut down water chiller and require manual reset:
- a. Low evaporator pressure or high condenser pressure.
 - b. Low chilled-water temperature.
 - c. Refrigerant high pressure.
 - d. High or low oil pressure.
 - e. High oil temperature.
 - f. Loss of chilled-water flow.

- g. Loss of condenser-water flow.
 - h. Control device failure.
18. BAS or DDC System Interface: Factory-install hardware and software to enable system to monitor, control, and display chiller status and alarms.
- a. Hardwired I/O Points:
 - 1) Monitoring: On/off status, **[common trouble alarm][electrical power demand (kilowatts)][electrical power consumption (kilowatt hours)]<Insert monitoring point>** .
 - 2) Control: On/off operation, **[chilled-water discharge temperature set-point adjustment][electrical power demand limit]<Insert control point>** .
 - b. Communication Interface: **[ASHRAE 135 (BACnet)][LonTalk][Modbus][Industry-accepted open-protocol]<Insert type of interface>** communication interface is to enable control system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel are to be available through DDC system for HVAC.
19. Factory-installed wiring outside of enclosures is to be in NFPA 70-complaint raceway. [**Make terminal connections with liquidtight or flexible metallic conduit.**]
- P. Accessories:
- 1. Factory-furnished **[neoprene][or][spring]** isolators [**with seismic restraints**] for field installation.
 - a. Spring Deflection: **[1 inch (25 mm)][2 inches (50 mm)]<Insert inches (mm)>** .
- Q. Capacities and Characteristics:
- 1. Capacity: **<Insert tons (kW)>** .
 - 2. Full-Load Efficiency:
 - a. COP: **<Insert number>** .
 - b. EER: **<Insert number>** .
 - c. Power Input/Cooling Output: **<Insert kW/ton (kW/kW)>** .
 - 3. Part-Load Efficiency:
 - a. IPLV: **<Insert number>** .
 - b. NPLV: **<Insert number>** .
 - 4. Low Ambient Operation: Chiller designed for operation to **[0 deg F (minus 18 deg C)][minus 20 deg F (minus 29 deg C)]<Insert temperature>** .
 - 5. High Ambient Operation: Chiller designed for operation to **[115 deg F (46 deg C)][120 deg F (50 deg C)]<Insert temperature>** .
 - 6. Evaporator:
 - a. Type: **[Braze plate][or][shell and tube]** .
 - b. Pressure Rating: **<Insert psig (kPa)>** .
 - c. Fluid Type: **[Water]<Insert fluid type>** .
 - d. Design Fluid Flow Rate: **<Insert gpm (L/s)>** .
 - e. Minimum Fluid Flow Rate: **<Insert gpm (L/s)>** .
 - f. Entering-Fluid Temperature: **<Insert deg F (deg C)>** .

- g. Leaving-Fluid Temperature: **<Insert deg F (deg C)>** .
 - h. Fluid Pressure Drop: **<Insert feet of head (kPa)>** .
 - i. Fouling Factor: **[0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert value>** .
- 7. Condenser Entering-Air Temperature: **<Insert deg F (deg C)>** .
 - 8. Site Altitude: **<Insert feet (m)>** .
 - 9. Heat Recovery Condenser:
 - a. Type: **[Braze plate][or][shell and tube]** .
 - b. Capacity: **<Insert MBH (kW)>** .
 - c. Pressure Rating: **<Insert psig (kPa)>** .
 - d. Fluid Type: **[Water]<Insert fluid type>** .
 - e. Design Fluid Flow Rate: **<Insert gpm (L/s)>** .
 - f. Minimum Fluid Flow Rate: **<Insert gpm (L/s)>** .
 - g. Entering-Fluid Temperature: **<Insert deg F (deg C)>** .
 - h. Leaving-Fluid Temperature: **<Insert deg F (deg C)>** .
 - i. Fluid Pressure Drop: **<Insert feet of head (kPa)>** .
 - j. Fouling Factor: **[0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)][0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W)]<Insert factor>** .
 - 10. Number of Refrigeration Circuits: **[One][Two]** .
 - 11. Hydronic Package:
 - a. Number of Pumps: **[One][Two]** .
 - b. Pump Control: **[Constant][Variable]** speed.
 - c. Pump Design Fluid Flow Rate: **<Insert gpm (L/s)>** .
 - d. Pump Dynamic Head: **<Insert feet of head (kPa)>** .
 - e. Pump Speed: **<Insert rpm>** .
 - f. Pump Motor Horsepower: **<Insert horsepower>** .
 - g. Storage Tank: **<Insert storage capacity>** .
 - 12. Compressor Rated Load Amperes: **<Insert value>** .
 - 13. Compressor Locked-Rotor Amperes: **<Insert value>** .
 - 14. Controls Power Connection: Fed through integral transformer.
 - 15. Chiller Power Input: **<Insert kilowatts>** .
 - 16. Chiller Minimum Circuit Ampacity: **<Insert value>** .
 - 17. Chiller Maximum Overcurrent Protection Device: **<Insert amperage>** .
 - 18. Chiller Electrical Characteristics: **[208][240][480][600]<Insert value>** -V ac, three phase, 60 Hz.
 - 19. Noise Rating: **<Insert dBA>** at **<Insert distance in feet (m)>** when measured in accordance with AHRI 370.

R. Materials:

- 1. Steel:
 - a. ASTM A36/A36M for carbon structural steel.
 - b. ASTM A568/A568M for steel sheet.
- 2. Stainless Steel:
 - a. Manufacturer's standard grade for casing.
 - b. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

3. Galvanized Steel: ASTM A653/A653M.
4. Aluminum: ASTM B209/B209M.
5. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
6. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a [3000]<Insert time> -hour salt-spray test in accordance with ASTM B117.
 - a. Standards:
 - 1) ASTM B117 for salt spray.
 - 2) ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m).
 - 3) ASTM D3359 for cross hatch adhesion of 5B.
 - b. Application: [Immersion][Spray] .
 - c. Thickness: [1 mil (0.025 mm)]<Insert value> .
 - d. Gloss: Minimum gloss of 60 on a 60-degree meter.

S. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system is to automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
2. See Drawings for equipment served by backup power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

T. Outdoor Installations:

1. Chiller is to be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a [25]<Insert time> -year period with minimal degradation due to exposure to outdoor ambient conditions.
2. Chillers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past [30]<Insert time> -year period.

U. Source Quality Control:

1. Perform functional test of water chillers before shipping.
2. Factory performance test water chillers, before shipping, in accordance with AHRI 550/590 (AHRI 551/591).
 - a. Test the following conditions:
 - 1) Design conditions indicated.
 - 2) AHRI 550/590 (AHRI 551/591) part-load points.
3. Factory performance test water chillers before shipping. Comply with the following in lieu of AHRI 550/590 (AHRI 551/591).
 - a. Allowable Capacity Tolerance: [Zero]<Insert number> percent.
 - b. Allowable Full-Load Energy Efficiency Tolerance: [Zero]<Insert number> percent.
 - c. Allowable Part-Load Energy Efficiency Tolerance: [Zero]<Insert number> percent.
 - d. Allow [Owner]<Insert entity> access to witness water chiller testing. Notify

[Owner]<Insert entity>[14][30]<Insert number> days in advance of testing.

4. Factory test and inspect evaporator [**and water-cooled condenser**] in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
5. For water chillers located outdoors, rate sound power level in accordance with AHRI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.
 1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF AIR-COOLED, SCROLL WATER CHILLERS

- A. Coordinate sizes and locations of bases with actual equipment provided. Cast anchor-bolt inserts into concrete bases.
- B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment provided.
- C. Install water chillers on support structure indicated.
- D. Equipment Mounting:
 1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Maintain manufacturer's recommended clearances for service and maintenance.
- F. Maintain clearances required by governing code.
- G. Chiller manufacturer's factory-trained service personnel are to charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
- H. Install separate devices furnished by manufacturer and not factory installed.
 1. Chillers shipped in multiple major assemblies are to be field assembled by chiller manufacturer's factory-trained service personnel.

3.3 PIPING CONNECTIONS

- A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements in Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Where installing piping adjacent to chillers, allow space for service and maintenance.
- D. Evaporator Fluid Connections:
 - 1. Connect to evaporator inlet with shutoff valve, [**strainer**,][**flexible connector**,] thermometer, and plugged tee with pressure gauge.
 - 2. Connect to evaporator outlet with shutoff valve, balancing valve, [**flexible connector**,] flow switch, thermometer, plugged tee with pressure gauge, [**flow meter**,] and drain connection with valve.
 - 3. Make connections to water chiller with a [**union**][**flange**][**or**][**mechanical coupling**] .
- E. Heat Recovery Condenser Fluid Connections:
 - 1. Connect to condenser inlet with shutoff valve, [**strainer**,][**flexible connector**,] thermometer, and plugged tee with pressure gauge.
 - 2. Connect to condenser outlet with shutoff valve, balancing valve, [**flexible connector**,] flow switch, thermometer, plugged tee with pressure gauge, [**flow meter**,] and drain connection with valve.
 - 3. Make connections to water chiller with a [**union**][**flange**][**or**][**mechanical coupling**] .
- F. Connect each drain connection with a drain valve full size of drain connection. [**Connect drain pipe to drain valve with union and extend drain pipe to terminate over floor drain.**]
- G. Connect each chiller vent connection with [**an automatic**][**or**][**a manual**] vent, full size of vent connection.
- H. Vent and purge air from hydronic systems, and ensure that expansion tank is properly charged with air to suit system Project requirements.

3.4 ELECTRICAL POWER CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Provide nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate is to be laminated phenolic layers of black with engraved white letters at least **1/2 inch (13 mm)** high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

- B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.
- C. Connect control wiring between chiller control interface and **[DDC system]<Insert system description>** for remote monitoring and control of chillers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- D. Provide nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate is to be laminated phenolic layers of black with engraved white letters at least **1/2 inch (13 mm)** high.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections **[with the assistance of a factory-authorized service representative] .**
- D. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Air-cooled scroll water chillers will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
- C. Complete installation and startup checks in accordance with manufacturer's written instructions and perform the following:
 - 1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
 - 2. Verify that pumps are installed and functional.
 - 3. Verify that thermometers and gauges are installed.
 - 4. Operate water chiller for run-in period.
 - 5. Check bearing lubrication and oil levels.
 - 6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
 - 7. Verify proper motor rotation.
 - 8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.

9. Verify and record performance of chilled- [**and heat recovery condenser-**] water flow and low-temperature interlocks.
 10. Verify and record performance of water chiller protection devices.
 11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- D. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.
- E. Prepare a written startup report that records results of tests and inspections.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. [**Video record the training sessions and provide electronic copy to Owner.**]
1. Instructor is to be factory trained and certified.
 2. Provide not less than **[eight]<Insert time>** hours of training.
 3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
 4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 5. Obtain Owner sign-off that training is complete.
 6. Hold Owner training at Project site.

END OF SECTION 23 64 23 13



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 64 23 13	23 64 23 16	Water-Cooled, Scroll Water Chillers



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 64 23 16 - WATER-COOLED, SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water-cooled, scroll water chillers.

B. Related Requirements:

1. Section 284400 "Refrigerant Detection and Alarm" for refrigerant monitors, alarms, supplemental breathing apparatus, and ventilation equipment interlocks.

1.2 DEFINITIONS

- A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- B. DDC: Direct digital control.
- C. EER: Energy efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
- D. IPLV: Integrated Part-Load Value. A single number part-load efficiency figure of merit for a single chiller calculated in accordance with the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.
- E. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
- F. NPLV: Nonstandard Part-Load Value. A single number part-load efficiency figure of merit for a single chiller calculated in accordance with the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
 - a. Performance at AHRI standard conditions and at conditions indicated.
 - b. Performance at AHRI standard unloading conditions.
 - c. Minimum evaporator and condenser flow rate.
 - d. Refrigerant capacity of water chiller.
 - e. Oil capacity of water chiller.
 - f. Fluid capacity of evaporator.
 - g. Fluid capacity of condenser.

- h. Characteristics of safety relief valves.
 - i. Minimum entering condenser-water temperature.
 - j. Performance at varying capacity with constant design condenser-water temperature. Repeat performance at varying capacity for different condenser-water temperatures from design to minimum in [5 deg F (3 deg C)]<Insert deg F (deg C)> increments.
 - k. Force and moment capacity of each piping connection.
 - B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:
 - 1. Assembled unit dimensions.
 - 2. Weight and load distribution.
 - 3. Required clearances for maintenance and operation.
 - 4. Size and location of piping and wiring connections.
 - 5. Wiring Diagrams: For power, signal, and control wiring.
 - C. Delegated Design Submittal: For water chiller supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Include design calculations for selecting vibration isolators[and seismic restraints] and for designing vibration isolation bases.
 - 2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
 - 3. Restraint Details: [Seismic-]detail fabrication and attachment of[wind and] seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
 - D. Sustainable Design Submittals:
 - 1. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
 - 2. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
 - 3. Product Data: For energy performance.
- ### 1.4 INFORMATIONAL SUBMITTALS
- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
 - B. Certificates: For certification required in "Quality Assurance" Article.
 - C. Seismic Qualification Data: Certificates, for water chillers, accessories, and components, from manufacturer. Submit certification that specified equipment will withstand wind forces identified in Section 018123 "Facility Seismic and Wind Criteria" and coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- D. Source quality-control test reports.
- E. Startup service reports.
- F. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.
- B. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Tool kit specially designed by chiller manufacturer for use in servicing chiller(s) to include the following:
 - 1. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
 - 2. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit." Text size is to be at least **1 inch (25 mm)** high.
 - 3. List of each tool furnished. Permanently attach the list to underside of case cover. Text size is to be at least **0.5 inch (13 mm)** high.
- B. Touch-up Paint: [**32 oz. (1 L)**]**<Insert volume>** container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.7 QUALITY ASSURANCE

- A. AHRI Certification: Certify chiller in accordance with AHRI 590 certification program.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.
- B. Package water chiller for export shipping.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.
 - 1. Extended warranties include, but are not limited to, the following:
 - a. Complete chiller including refrigerant and oil charge.
 - b. Complete compressor and drive assembly including refrigerant and oil charge.
 - c. Refrigerant[**and oil**] charge.
 - 1) Loss of refrigerant charge for any reason due to manufacturer product defect and product installation.

- d. Parts **[only][and labor]**.
- 2. Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for chillers, including comprehensive engineering analysis.
- B. Seismic Performance: Scroll water chillers to withstand the effects of earthquake motions. See Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- C. Condenser-Fluid Temperature Performance:
 - 1. Startup Condenser-Fluid Temperature: Chiller is to be capable of starting with an entering condenser-fluid temperature of **[60 deg F (16 deg C)][55 deg F (13 deg C)][40 deg F (4 deg C)]<Insert temperature>** and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
 - 2. Minimum Operating Condenser-Fluid Temperature: Chiller is to be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of **[65 deg F (18 deg C)][60 deg F (16 deg C)][55 deg F (13 deg C)]<Insert temperature>**.
 - 3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
- D. Site Altitude: Chiller is to be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
- E. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:
 - 1. Allowable Capacity Tolerance: **[Zero]<Insert number>** percent.
 - 2. Allowable Full-Load Energy Efficiency Tolerance: **[Zero]<Insert number>** percent.
 - 3. Allowable Part-Load Energy Efficiency Tolerance: **[Zero]<Insert number>** percent.
- F. AHRI Rating: Rate water chiller performance in accordance with requirements in AHRI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
- G. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
- H. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

- I. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- J. Comply with requirements of UL 1995 "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.
- K. ASME Compliance: Fabricate and label water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
- L. Operation Following Loss of Normal Power:
 - 1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system is to automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored, either through a backup power source or through normal power if restored before backup power is brought on-line.
 - 2. See Drawings for equipment served by backup power systems.
 - 3. Provide means and methods required to satisfy requirement even if not explicitly indicated.
- M. Outdoor Installations:
 - 1. Chiller is to be suitable for outdoor installation indicated with adequate weather protection to ensure reliable service life over a **[25]<Insert value>**-year period with minimal degradation due to exposure to outdoor ambient conditions.
 - 2. Chillers is to be equipped for safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database. Equipment is to be capable of operating at extreme outdoor temperatures recorded over past **[30]<Insert value>**-year period.

2.2 WATER-COOLED, SCROLL WATER CHILLERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Carrier Global Corporation]**
 - 2. **[Daikin Applied]**
 - 3. **[WaterFurnace International, Inc.]**
 - 4. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Carrier Global Corporation]**
 - 2. **[Daikin Applied]**
 - 3. **[WaterFurnace International, Inc.]**
 - 4. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 - 5. **<Insert manufacturer's name>**
- C. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.



- D. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.
- E. Compressor-Drive Assemblies:
1. Compressors:
 - a. Description: Positive-displacement direct drive with hermetically sealed casing.
 - b. Each compressor is to have suction and discharge service valves, crankcase oil heater, and suction strainer.
 - 1) For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.
 - c. Operating Speed: Nominal 3600 rpm for 60 Hz applications.
 - d. Capacity Control: On-off compressor cycling[, **plus hot-gas bypass**].
 - 1) Digital compressor unloading is an acceptable alternative to achieve capacity control.
 - 2) Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge.
 - 3) Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.
 - e. Vibration Isolation: Mount individual compressors on vibration isolators.
 - 1) For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.
 - 2) Sound-reduction package is to consist of acoustic enclosures around the compressors that are designed to reduce sound level without affecting performance.
 - f. Compressor Motors:
 - 1) Hermetically sealed and cooled by refrigerant suction gas.
 - 2) High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
 - 3) Compressor Motor Controllers:
 - g. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
 - F. Refrigeration System:
 1. Refrigerant Type: **<Insert refrigerant type>**.
 2. Refrigerant Compatibility: Parts exposed to refrigerants are to be fully compatible with refrigerants, and pressure components are to be rated for refrigerant pressures.
 3. Refrigerant Circuit: Each circuit is to include [**an electronic**][**or**][**a thermal**]-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
 4. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
 - a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in each circuit in lieu of each compressor.

5. Pressure Relief Device:

- a. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- b. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
- c. Device is to be ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Each heat exchanger is to be equipped with pressure relief valve(s).

G. Evaporator:

1. Brazed-plate or shell-and-tube design, as indicated.
2. Shell and Tube:
 - a. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
 - b. Code Compliance: Tested and stamped in accordance with ASME Boiler and Pressure Vessel Code.
 - c. Shell Material: Carbon steel.
 - d. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
 - e. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping. **[Furnish flange adapters to mate to flanged piping.]**
 - f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
3. Brazed Plate:
 - a. Direct-expansion, single-pass, brazed-plate design.
 - b. **[Type 304][or][Type 316]** stainless steel construction.
 - c. Code Compliance: Tested in accordance with ASME Boiler and Pressure Vessel Code.
 - d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
 - e. Inlet Strainer: Factory-furnished **[20][or][40]<Insert value>** mesh strainer for field installation in supply piping to evaporator. Manufacturer has option to factory install strainer.

H. Condenser:

1. Brazed plate, shell and tube, or without integral condenser; as indicated.
2. Shell and Tube:
 - a. Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.
 - b. Positive subcooling of liquid refrigerant.
 - c. Code Compliance: Tested and stamped in accordance with ASME Boiler and Pressure Vessel Code.
 - d. Shell Material: Carbon steel.
 - e. Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping. **[Furnish flange adapters to mate to flanged piping.]**
 - f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
 - g. Each condenser is to have a pressure relief device, purge cock, and liquid-line shutoff valve.

3. Brazed Plate:
 - a. Direct-expansion, single-pass, brazed-plate design for positive subcooling of liquid refrigerant.
 - b. Type 316 stainless steel construction.
 - c. Code Compliance: Tested in accordance with ASME Boiler and Pressure Vessel Code.
 - d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
 - e. Inlet Strainer: Factory-furnished [20][or][40]<Insert value> mesh strainer for field installation in supply piping to condenser. Manufacturer has option to factory install strainer.
4. Condenserless Chiller: Designed for field connection to remote condenser. Coordinate requirements with Section 236313 "Air-Cooled Refrigerant Condensers."

I. Insulation:

1. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C534, Type 1 for tubular materials and Type 2 for sheet materials.
 - a. Thickness: [3/4 inch (19 mm)][1-1/2 inches (38 mm)]<Insert thickness>.
2. Adhesive: As recommended by insulation manufacturer.
3. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components are to include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
 - a. Apply adhesive to 100 percent of insulation contact surface.
 - b. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
 - c. Seal seams and joints for a vapor barrier.
 - d. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
 - e. Manufacturer has option to factory- or field-insulate chiller components of chillers to reduce potential for damage during installation.
 - f. Field-Applied Insulation:
 - 1) Components that are not factory insulated are to be field insulated to comply with requirements indicated.
 - 2) Manufacturer is to be responsible for chiller insulation whether factory or field installed to ensure manufacturer is the single point of responsibility for chillers.
 - 3) Manufacturer factory-authorized service representative is to instruct and supervise installation of field-applied insulation.
 - 4) After field-applied insulation is complete, paint insulation to match factory-applied finish.

2.3 ELECTRICAL

- A. Factory installed and wired, and functionally tested at factory before shipment.
- B. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary are to provide a single-point field power connection to water chiller.

- C. House in a unit-mounted, NEMA 250, **[Type 1]<Insert type>** enclosure with hinged access door with lock and key or padlock and key.
- D. Wiring is to be numbered and color-coded to match wiring diagram.
- E. Install factory wiring located outside of an enclosure in a **[metal]** raceway. Make terminal connections with not more than a **24-inch (610-mm)** length of **[liquidtight][or][flexible metallic]** conduit.
- F. Field power interface is to be to **[wire lugs][NEMA KS 1, heavy-duty, nonfused disconnect switch][circuit breaker]**. Minimum short circuit current rating (SCCR) in accordance with UL 508 is to be as required by electrical power distribution system, but not less than **[42,000][65,000][100,000]<Insert value> A**.
- G. Each motor is to have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:
 - 1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses for Type 2 protection in accordance with IEC 60947-4-1.
 - 2. NEMA KS 1, heavy-duty, nonfusible switch.
 - 3. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- H. Each motor is to have overcurrent protection.
- I. Overload relay sized in accordance with UL 1995, or an integral component of water chiller control microprocessor.
- J. Phase Failure and Undervoltage: Solid-state sensing with adjustable settings.
- K. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
- L. Control Relays: Auxiliary and adjustable time-delay relays, or an integral component to water chiller microprocessor.
- M. Indicate the following for water chiller electrical power supply:
 - 1. Current, phase to phase, for all three phases.
 - 2. Voltage, phase to phase and phase to neutral for all three phases.
 - 3. Three-phase real power (kilowatts).
 - 4. Three-phase reactive power (kilovolt amperes reactive).
 - 5. Power factor.
 - 6. Running log of total power versus time (kilowatt hours).
 - 7. Fault log, with time and date of each.
 - 8. **<Insert features>**.

2.4 CONTROLS

- A. Factory installed and wired, and functionally tested at factory before shipment.
- B. Standalone, microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
- C. Enclosure: Share enclosure with electrical power devices or include a separate enclosure of matching

construction.

- D. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:

1. Date and time.
2. Operating or alarm status.
3. Operating hours.
4. Outside-air temperature if required for chilled-water reset.
5. Temperature and pressure of operating set points.
6. Entering and leaving temperatures of chilled water.
7. Entering and leaving temperatures of condenser water.
8. Refrigerant pressures in evaporator and condenser.
9. Saturation temperature in evaporator and condenser.
10. No cooling load condition.
11. Elapsed time meter (compressor run status).
12. Pump status.
13. Antirecycling timer status.
14. Percentage of maximum motor amperage.
15. Current-limit set point.
16. Number of compressor starts.
17. Alarm history with retention of operational data before unit shutdown.
18. Superheat.
19. **<Insert items>**.

- E. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Capacity control based on evaporator leaving-fluid temperature.
3. Capacity control compensated by rate of change of evaporator entering-fluid temperature.
4. Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature is to be reset based on **[return-water][outside-air][space]<Insert variable>** temperature.
5. Current limit and demand limit.
6. Condenser-water temperature.
7. External water chiller emergency stop.
8. Antirecycling timer.
9. Automatic lead-lag switching.
10. Ice-building mode.
11. **<Insert functions>**.

- F. Manual-Reset Safety Controls: The following conditions are to shut down water chiller and require manual reset:

1. Low evaporator pressure or high condenser pressure.
2. Low chilled-water temperature.
3. Refrigerant high pressure.
4. High or low oil pressure.
5. High oil temperature.
6. Loss of chilled-water flow.
7. Loss of condenser-water flow.
8. Control device failure.
9. **<Insert items>**.

- G. System Interface: **[Building Automation][DDC]**. Factory install hardware and software to enable

system to monitor, control, and display chiller status and alarms.

1. Hardwired I/O Points:
 - a. Monitoring: On/off status, [common trouble alarm][electrical power demand (kilowatts)][electrical power consumption (kilowatt hours)]<Insert monitoring point>.
 - b. Control: On/off operation, [chilled-water discharge temperature set-point adjustment][electrical power demand limit]<Insert control point>.
 2. Communication Interface: [ASHRAE 135 (BACnet)][LonTalk][Modbus][Industry-accepted open-protocol]<Insert type of interface> communication interface is to enable control system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel are to be available through DDC system for HVAC.
- H. Factory-installed wiring outside of enclosures is to be in an NFPA 70 complaint raceway. [**Make terminal connections with liquidtight or flexible metallic conduit.**]

2.5 ACCESSORIES

- A. Factory-furnished, chilled-[**and condenser-**]water [paddle][or][pressures differential] type flow switches for field installation.
 1. Manufacturer has option to factory install switches.
- B. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
 1. Pressure measurement and display through chiller integral controls is an acceptable alternative.
- C. Factory-furnished [neoprene][or][spring] isolators [with seismic restraints] for field installation.

2.6 CAPACITIES AND CHARACTERISTICS

- A. Capacity: <Insert tons (kW)>.
- B. Full-Load Efficiency:
 1. COP: <Insert number>.
 2. EER: <Insert number>.
 3. Power Input/Cooling Output: <Insert kW/ton (kW/kW)>.
- C. Part-Load Efficiency:
 1. IPLV: <Insert number>.
 2. NPLV: <Insert number>.
- D. Evaporator:
 1. Type: [Brazen plate][Shell and tube][Brazen plate or shell and tube].
 2. Pressure Rating: <Insert psig (kPa)>.
 3. Fluid Type: [Water]<Insert fluid type>.
 4. Design Fluid Flow Rate: <Insert gpm (L/s)>.

5. Minimum Fluid Flow Rate: **<Insert gpm (L/s)>**.
6. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
7. Leaving-Fluid Temperature: **<Insert deg F (deg C)>**.
8. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.
9. Fouling Factor: **[0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert value>**.

E. Condenser:

1. Type: **[Brazen plate][Shell and tube][Chiller without integral condenser]**.
2. Pressure Rating: **<Insert psig (kPa)>**.
3. Fluid Type: **[Water]<Insert fluid type>**.
4. Design Fluid Flow Rate: **<Insert gpm (L/s)>**.
5. Minimum Fluid Flow Rate: **<Insert gpm (L/s)>**.
6. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
7. Leaving-Fluid Temperature: **<Insert deg F (deg C)>**.
8. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.
9. Fouling Factor: **[0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert factor>**.

F. Number of Refrigeration Circuits: **[One][Two]**.

G. Compressor Rated Load Amperes: **<Insert value>**.

H. Compressor Locked-Rotor Amperes: **<Insert value>**.

I. Controls Power Connection: Fed through integral transformer.

J. Chiller Power Input: **<Insert kilowatts>**.

K. Chiller Minimum Circuit Ampacity: **<Insert value>**.

L. Chiller Maximum Overcurrent Protection Device: **<Insert amperage>**.

M. Chiller Electrical Characteristics: **[208][240][480][600]<Insert value>-V ac, three phase, 60 Hz.**

N. Noise Rating: **<Insert dBA>** at **<Insert distance in feet (m)>** when measured in accordance with AHRI 575.

2.7 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Factory performance test water chillers, before shipping, in accordance with AHRI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

1. Test the following conditions:

- a. Design conditions indicated.

- b. AHRI 550/590 part-load points.
 - c. <Insert test points>.
- 2. Allow [Owner]<Insert entity> access to place where water chillers are being tested. Notify [Owner]<Insert entity>[14][30]<Insert number> days in advance of testing.
- C. Factory test and inspect evaporator[and water-cooled condenser] in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
- D. For water chillers located indoors, rate sound power level in accordance with AHRI 575 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.
 - 1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF WATER-COOLED, SCROLL WATER CHILLERS

- A. Coordinate sizes and locations of bases with actual equipment to be installed. Cast anchor-bolt inserts into concrete bases.
- B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment to be installed.
- C. Install water chillers on support structure indicated.
- D. Equipment Mounting:
 - 1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Maintain manufacturer's recommended clearances for service and maintenance.
- F. Maintain clearances required by governing code.
- G. Chiller manufacturer's factory-trained service personnel are to charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
- H. Install separate devices furnished by manufacturer and not factory installed.

1. Chillers shipped in multiple major assemblies are to be field assembled by chiller manufacturer's factory-trained service personnel.

3.3 PIPING CONNECTIONS

- A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements in Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Where installing piping adjacent to chillers, allow space for service and maintenance.
- D. Evaporator Fluid Connections:
 1. Connect to evaporator inlet with shutoff valve, [**strainer**,] [**flexible connector**,] thermometer, and plugged tee with pressure gage.
 2. Connect to evaporator outlet with shutoff valve, balancing valve, [**flexible connector**,] flow switch, thermometer, plugged tee with pressure gage, [**flow meter**,] and drain connection with valve.
 3. Make connections to water chiller with a [**union**] [**flange**] [**mechanical coupling**] [**union, flange, or mechanical coupling**].
- E. Condenser Fluid Connections:
 1. Connect to condenser inlet with shutoff valve, [**strainer**,] [**flexible connector**,] thermometer, and plugged tee with pressure gage.
 2. Connect to condenser outlet with shutoff valve, balancing valve, [**flexible connector**,] flow switch, thermometer, plugged tee with pressure gage, [**flow meter**,] and drain connection with valve.
 3. Make connections to water chiller with a [**union**] [**flange**] [**mechanical coupling**] [**union, flange, or mechanical coupling**].
- F. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15.
- G. Connect each drain connection with a drain valve, full size of drain connection. [**Connect drain pipe to drain valve with union and extend drain pipe to terminate over floor drain.**]
- H. Connect each chiller vent connection with [**an automatic**] [**or**] [**a manual**] vent, full size of vent connection.

3.4 ELECTRICAL POWER CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate is to be laminated phenolic layers of black with engraved white letters at least 0.5 inch high. Locate nameplate where easily visible.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between chillers and other equipment to interlock operation as required for a complete and functioning system.
- C. Connect control wiring between chiller control interface and **[DDC System]<Insert system description>** for remote monitoring and control of chillers. Comply with requirements in **[Section 230923 "Direct Digital Control (DDC) System for HVAC."]<Insert Section.>**
- D. Install nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate is to be laminated phenolic layers of black with engraved white letters at least 0.5 inch high.

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
- C. Complete installation and startup checks in accordance with manufacturer's written instructions and perform the following:
 - 1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
 - 2. Verify that pumps are installed and functional.
 - 3. Verify that thermometers and gages are installed.
 - 4. Operate water chiller for run-in period.
 - 5. Check bearing lubrication and oil levels.
 - 6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
 - 7. Verify proper motor rotation.
 - 8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
 - 9. Verify and record performance of chilled- and condenser-water flow and low-temperature interlocks.
 - 10. Verify and record performance of water chiller protection devices.
 - 11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- D. Inspect field-assembled components; equipment installation; and piping, controls, and electrical connections for proper assembly, installation, and connection.
- E. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.
- F. Prepare a written startup report that records results of tests and inspections.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. **[Video record the training sessions and provide electronic copy to Owner.]**

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



1. Instructor is to be factory trained and certified.
2. Provide not less than **[eight]<Insert value>** hours of training.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training is to be held at Project site.

END OF SECTION 23 64 23 16



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 64 23 16	23 64 23 13	Air-Cooled, Scroll Water Chillers



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 64 26 13 - AIR-COOLED, ROTARY-SCREW WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Packaged, air-cooled chillers.
 2. Packaged, portable refrigerant recovery units.
 3. Heat-exchanger, brush-cleaning system.

1.2 DEFINITIONS

- A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- B. DDC: Direct digital control.
- C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
- D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated in accordance with the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.
- E. kW/Ton (kW/kW): The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in **tons (kW)** at any given set of rating conditions.
- F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated in accordance with the method defined by AHRI 550/590 and intended for operating conditions other than AHRI standard rating conditions.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
 - a. Performance at AHRI standard conditions and at conditions indicated.
 - b. Performance at AHRI standard unloading conditions.
 - c. Minimum evaporator flow rate.
 - d. Refrigerant capacity of chiller.
 - e. Oil capacity of chiller.
 - f. Fluid capacity of evaporator.
 - g. Characteristics of safety relief valves.
 - h. Minimum entering condenser-air temperature.
 - i. Maximum entering condenser-air temperature.
 - j. Performance at varying capacities with constant-design, entering condenser-air

temperature. Repeat performance at varying capacities for different entering condenser-air temperatures from design to minimum in [10 deg F (6 deg C)]<Insert temperature> increments.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittal: For water chiller supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Restraint Details: [**Wind-**][**and**][**seismic-**]detail fabrication and attachment of[**wind and**] seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

D. Sustainable Design Submittals:

1. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
2. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
3. Product Data: For energy performance.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Certificates: For certification required in "Quality Assurance" Article.

C. Seismic Qualification Data: Certificate, for chillers, accessories, and components, from manufacturer. Submit certification that specified equipment will withstand wind forces identified in Section 018123 "Facility Seismic and Wind Criteria" and coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control reports.

E. Field Test Reports: Include startup service reports.



- F. Sample Warranty: For AHRI special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. AHRI Certification: Certify chiller in accordance with AHRI 550/590 certification program.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Ship chillers from the factory fully charged with refrigerant.
- B. Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.
- C. Ship each oil-lubricated chiller with a full charge of oil.
1. Ship oil **[factory installed in chiller][in containers separate from chiller]**.
- D. Package chiller for export shipping in totally enclosed **[crate][and][bagging]**.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
1. Extended warranties include, but are not limited to, the following:
- a. Complete chiller including refrigerant and oil charge.
 - b. Complete compressor and drive assembly including refrigerant and oil charge.
 - c. Refrigerant **[and oil]** charge.
 - d. Parts **[only][and labor]**.
 - e. Loss of refrigerant charge for any reason.
2. Warranty Period: **[Two][Three][Four][Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for chillers, including comprehensive engineering analysis.
- B. Wind-Restraint Performance:

1. See Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for building classification criteria.
 - C. Seismic Performance: Rotar-screw chillers to withstand the effects of earthquake motions. See Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
 - D. Site Altitude: Chiller is to be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
 - E. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:
 1. Allowable Capacity Tolerance: **[Zero]<Insert number>** percent.
 2. Allowable IPLV/NPLV Performance Tolerance: **[Zero]<Insert number>** percent.
 - F. AHRI Rating: Rate chiller performance in accordance with requirements in AHRI 550/590.
 - G. ASHRAE Compliance:
 1. ASHRAE 15 for safety code for mechanical refrigeration.
 - H. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
 - I. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code.
 - J. Comply with NFPA 70.
 - K. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.
- ### 2.2 PACKAGED, AIR-COOLED CHILLERS
- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Carrier Global Corporation]**
 2. **[Daikin Applied]**
 3. **[Dunham-Bush, Inc]**
 4. **[Trane]**
 5. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 6. **<Insert manufacturer's name>**
 - B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [Carrier Global Corporation]
 2. [Daikin Applied]
 3. [Dunham-Bush, Inc]
 4. [Trane]
 5. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 6. <Insert manufacturer's name>
- C. Description: Factory-assembled and run-tested chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
- D. Fabricate base, frame, and attachment to chiller components strong enough to resist chiller movement during a seismic event when chiller base is anchored to field support structure.
- E. Cabinet:
1. Base: Galvanized-steel base extending the perimeter of chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
 2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported by base.
 3. Casing: Galvanized steel.
 4. Finish: Coat base, frame, and casing with a corrosion-resistant coating.
 5. Sound-reduction package designed to reduce sound level without affecting performance and consisting of the following:
 - a. Acoustic enclosure around compressors.
 - b. Reduced-speed fans with acoustic treatment.
 6. Security Package: Provide removable [grilles][louvered panels] with fasteners for additional protection of compressors, evaporator, and condenser coils without inhibiting service access. Finish to match cabinet.
- F. Compressors:
1. Description: Positive displacement, hermetically sealed.
 2. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
 3. Rotors: Manufacturer's standard one- or two-rotor design.
 4. Each compressor provided with[**suction and**] discharge shutoff valves, crankcase oil heater, and suction strainer.
- G. Service: Easily accessible for inspection and service.
- H. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.
1. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
 2. Operating Range: From 100 to [20][15][10][5][zero]<Insert number> percent of design capacity.
 3. Condenser-Air Unloading Requirements over Operating Range: [**Constant-design, entering condenser-air temperature**][**Drop-in, entering condenser-air temperature of 5 deg F (3 deg C) drop for each 10 percent in capacity reduction**]<Insert conditions>.
 4. For units equipped with a variable-frequency controller, capacity control are to be both "valveless" and "stepless," requiring no slide valve or capacity-control valve(s) to operate at reduced capacity.
- I. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power

connection, and controls.

1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
2. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
3. Factory-installed and pressure-tested piping with isolation valves and accessories.
4. Oil compatible with refrigerant and chiller components.
5. Positive visual indication of oil level.

J. Vibration Control:

1. Vibration Balance: Balance chiller compressors and drive assemblies to provide a precision balance that is free of noticeable vibration over the entire operating range.
 - a. Overspeed Test: 25 percent above design operating speed.
2. Isolation: Mount individual compressors on vibration isolators.

K. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, induction type with inherent thermal-overload protection on each phase.

L. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
2. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.
3. Solid-state controller.
4. Variable-Frequency Controller:
 - a. Motor controller is to be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
 - b. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
 - c. Enclosure: Unit mounted, NEMA 250, **[Type 3R]<Insert type>**, with hinged full-front access door with lock and key.
 - d. Integral Disconnecting Means: **[Door-interlocked,]** UL 489, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating is to be as required by electrical power distribution system, but not less than **[42,000][65,000][100,000]<Insert value>** A.
 - e. Technology: Pulse-width-modulated output suitable for constant or variable torque loads.
 - f. Motor current at start is not to exceed the rated load amperes, providing no electrical inrush.

M. Refrigeration System:

1. Refrigerant: **[R-513A, ASHRAE 34 Safety Group A1][R-1234ze(E), ASHRAE Safety Group A2L]<Insert type>**.
2. Refrigerant Compatibility: Chiller parts exposed to refrigerants are to be fully compatible with refrigerants, and pressure components are to be rated for refrigerant pressures.
3. Refrigerant Circuit: Each circuit is to include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor **[suction]** and discharge shutoff valves, a liquid-line shutoff valve, a **[replaceable-core]** filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
4. Pressure Relief Device:

- a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- b. ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.

N. Evaporator:

1. Description: Shell-and-tube design.
 - a. Direct-expansion type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
 - b. Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.
2. Code Compliance: Tested and stamped in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Shell Material: Carbon steel.
4. Shell Heads: Removable carbon-steel heads located at each end of the tube bundle.
5. Fluid Nozzles: Terminated with **[mechanical-coupling][flanged]** end connections for connection to field piping.
6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
7. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to **minus 20 deg F (minus 29 deg C)**.
8. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.

O. Air-Cooled Condenser:

1. Plate-fin coil with integral subcooling on each circuit, rated at **450 psig (3103 kPa)**.
 - a. Construct coil casing of **[galvanized][or][stainless]** steel.
 - b. Construct coils of copper tubes mechanically bonded to **[aluminum][aluminum with precoated epoxy-phenolic][copper]** fins.
 - c. Coat coils with a corrosion-resistant coating after fabrication.
 - d. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
2. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
3. Fan Motors: Totally enclosed nonventilating or totally enclosed air over enclosure, with permanently lubricated bearings. Equip each motor with overload protection integral to either the motor or chiller controls.
4. Fan Guards: Steel safety guards with **[PVC][corrosion-resistant coating]**.

P. Corrosion-Resistant Coating: Apply a corrosion-resistant coating capable of withstanding a **[3,000]<Insert time>-hour salt-spray test in accordance with ASTM B117 to base, frame, and casing.**

1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of **100 in lb (11.3 N m)**.
 - c. ASTM B3359 for cross-hatch adhesion of 5B.
2. Application: **[Immersion][Spray]**.
3. Thickness: **[1 mil]<Insert measurement>**.
4. Gloss: Minimum of 50 gloss units on a single-angle, 60-degree meter.

5. UV Protection: Spray-applied topcoat.

Q. Electrical Power:

1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary are to provide a [multipoint][single-point], field-power connection to chiller.
2. House in a unit-mounted, NEMA 250, [Type 3R]<Insert type> enclosure with hinged access door[**with lock and key or padlock and key**].
3. Wiring is to be numbered[**and color-coded**] to match wiring diagram.
4. Install factory wiring outside of an enclosure in a raceway.
5. Field-power interface is to be [wire lugs][**NEMA KS 1, heavy-duty, nonfused disconnect switch**][**UL 489, instantaneous-trip circuit breaker with lockable handle**].
 - a. Disconnect means is to be interlocked with door operation.
 - b. Minimum withstand rating is to be as required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
 - a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.
 - b. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
7. Provide each motor with overcurrent protection.
8. Overload relay sized in accordance with UL 1995 or an integral component of chiller control microprocessor.
9. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.
10. Provide power factor correction capacitors to correct power factor to [0.90][0.95]<Insert value> at full load.
11. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
 - a. Power unit-mounted controls where indicated.
 - b. Power unit-mounted, ground fault interrupt duplex receptacle.
12. Control Relays: Auxiliary and adjustable time-delay relays.
13. For chiller electrical power supply, indicate the following:
 - a. Current and phase to phase for all three phases.
 - b. Voltage, phase to phase, and phase to neutral for all three phases.
 - c. Three-phase real power (kilowatts).
 - d. Three-phase reactive power (kilovolt amperes reactive).
 - e. Power factor.
 - f. Running log of total power versus time (kilowatt-hours).
 - g. Fault log, with time and date of each.
 - h. <Insert features>.

R. Controls:

1. Standalone and microprocessor based.
2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure[**for remote mounting in the field**].
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of

information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:

- a. Date and time.
 - b. Operating or alarm status.
 - c. Operating hours.
 - d. Outdoor-air temperature if required for chilled-water reset.
 - e. Temperature and pressure of operating set points.
 - f. Entering and leaving temperatures of chilled water.
 - g. Refrigerant pressures in evaporator and condenser.
 - h. Saturation temperature in evaporator and condenser.
 - i. No cooling load condition.
 - j. Elapsed time meter (compressor run status).
 - k. Pump status.
 - l. Antirecycling timer status.
 - m. Percent of maximum motor amperage.
 - n. Current-limit set point.
 - o. Number of compressor starts.
 - p. **<Insert items>**.
4. Control Functions:
 - a. Manual or automatic startup and shutdown time schedule.
 - b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature is to be reset based on **[return-water][outdoor-air][space]** temperature.
 - c. Current limit and demand limit.
 - d. External chiller emergency stop.
 - e. Antirecycling timer.
 - f. Automatic lead-lag switching.
 - g. Variable evaporator flow.
 - h. Thermal storage.
 - i. **<Insert control functions>**.
5. Manually Reset Safety Controls: The following conditions are to shut down chiller and require manual reset:
 - a. Low evaporator pressure or high condenser pressure.
 - b. Low chilled-water temperature.
 - c. Refrigerant high pressure.
 - d. High or low oil pressure.
 - e. High oil temperature.
 - f. Loss of chilled-water flow.
 - g. Control device failure.
 - h. **<Insert manually reset safety controls>**.
6. Trending: Capability to trend analog data of up to **[five]<Insert number>** parameters simultaneously over an adjustable period and frequency of polling.
7. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
9. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.

- a. Hardwired Points:
 - 1) Monitoring: On-off status, [common trouble alarm][electrical power demand (kilowatts)][electrical power consumption (kilowatt-hours)]<Insert monitoring point>.
 - 2) Control: On-off operation, [chilled-water, discharge temperature set-point adjustment][electrical power demand limit]<Insert control point>.
- b. [ASHRAE 135 (BACnet)][LonTalk][Modbus][Industry-accepted, open-protocol]<Insert type of interface> communication interface with the DDC system for HVAC is to enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel are to be available through the DDC system for HVAC.

S. Insulation:

- 1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C534, Type I for tubular materials and Type II for sheet materials.
- 2. Thickness: [3/4 inch (19 mm)][1-1/2 inches (38 mm)]<Insert dimension>.
- 3. Factory-applied insulation over cold surfaces of chiller components.
 - a. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
- 4. Apply protective coating to exposed surfaces of insulation to protect insulation from weather.

T. Accessories:

- 1. Factory-furnished, chilled-water flow switches for field installation.
- 2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
- 3. Factory-furnished [neoprene][or][spring] isolators for field installation.
- 4. Tool Kit: Chiller manufacturer is to assemble a tool kit specially designed for use in serving the chiller(s) furnished. Include special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance. Place tools in a lockable case with hinged cover. Provide a list of each tool furnished and attach the list to underside of case cover.

U. Capacities and Characteristics:

- 1. Capacity: <Insert tons (kW)>.
- 2. Full-Load Efficiency COP: <Insert value>.
- 3. Full-Load Efficiency (EER): <Insert value>.
- 4. Full-Load Efficiency (Power Input/Cooling Output): <Insert kW/ton (kW/kW)>.
- 5. Part-Load Efficiency (IPLV): <Insert value>.
- 6. Part-Load Efficiency (NPLV): <Insert value>.
- 7. Low Ambient Operation: Chiller designed for operation to [0 deg F (minus 18 deg C)]<Insert temperature>.
- 8. High Ambient Operation: Chiller designed for operation to [115 deg F (46 deg C)]<Insert temperature>.
- 9. Evaporator:
 - a. Configuration: [Integral to chiller][Shipped loose for field installation].
 - b. Pressure Rating: [150 psig (1034 kPa)][300 psig (2068 kPa)]<Insert value>.
 - c. Fluid Type: [Water]<Insert fluid type>.

- d. Design Fluid Flow Rate: **<Insert gpm (L/s)>**.
 - e. Minimum Fluid Flow Rate: **<Insert gpm (L/s)>**.
 - f. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
 - g. Leaving-Fluid Temperature: **<Insert deg F (deg C)>**.
 - h. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.
 - i. Fluid Velocity: **<Insert fps (m/s)>**.
 - j. Fouling Factor: **[0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert value>**.
- 10. Condenser Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - 11. Condenser Fan External Static Pressure: **<Insert wg (Pa)>**.
 - 12. Site Altitude: **<Insert feet (m)>**.
 - 13. Number of Refrigerant Circuits: **[Two][Each compressor on an independent circuit]<Insert requirement>**.
 - 14. Compressor:
 - a. Number of Compressors: **<Insert number>**.
 - b. Rated Load Amperes: **<Insert value>**.
 - c. Locked-Rotor Amperes: **<Insert value>**.
 - 15. Control Electrical Requirements:
 - a. Power Connection: **[Fed through integral transformer][Separate field-power connection]**.
 - b. Power Input: **<Insert kilowatts>**.
 - c. Minimum Circuit Ampacity: **<Insert value>**.
 - d. Maximum Overcurrent Protection Device: **<Insert amperage>**.
 - e. Volts: **[120]<Insert value>-V ac**.
 - f. Phase: Single.
 - g. Hertz: 60.
 - 16. Chiller Electrical Requirements:
 - a. Power Input: **<Insert kilowatts>**.
 - b. Power Factor: **<Insert value>**.
 - c. Minimum Circuit Ampacity: **<Insert value>**.
 - d. Maximum Overcurrent Protection Device: **<Insert amperage>**.
 - e. Volts: **[208][240][480][600]<Insert value>**.
 - f. Phase: Three.
 - g. Hertz: 60.
 - 17. Noise Rating: **<Insert number> dBA at <Insert distance in feet (m)>** when measured in accordance with AHRI 370. Provide factory-installed sound treatment if necessary to achieve the performance indicated.

2.3 PACKAGED, PORTABLE REFRIGERANT RECOVERY UNITS

- A. Packaged, portable unit consisting of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit is to be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest chiller furnished.

2.4 HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM

- A. Furnish for field installation a brush-cleaning system on each chiller **[condenser]<Insert heat exchanger>** for tube cleaning and improved heat transfer.
- B. System is to maintain tube fouling at or below design conditions without interrupting normal equipment operation.
- C. System is to consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve is to operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator is to be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle is to be set up to match Project requirements.
- D. Components:
 - 1. Brush: Each brush is to have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube is not to exceed **0.025 inch (0.6 mm)**.
 - 2. Basket: Single-piece polypropylene basket with neck OD to press fit ID of tube. Design is to provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
 - 3. Four-Way Valve:
 - a. Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
 - b. Configure valve with parallel flow connections to minimize field installation piping.
 - c. Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
 - d. Pipe connections are to be flanged.
 - e. Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
 - f. Hydrostatically test to 1.5 times the design working pressure.
 - g. Design the valve to cause no more than **0.5 psig (3 kPa)** pressure drop at design flow conditions.
 - h. Provide valve with valve-mounted indicating/warning light, which is to light before valve begins rotation.
 - i. Valve Actuator:
 - 1) Mount electric actuator to operate valve.
 - 2) Mount pneumatic piston-type actuator to operate valve. Actuator is to be suitable for operation using field-supplied air pressure.
 - j. Position Switches: Factory mount microswitches on valve to indicate the complete turn of valve in both normal and reverse flow.
 - 4. Control Panel: Factory or field mount a control panel on chiller. Control panel is to include the following features:
 - a. NEMA 250, **[Type 1][Type 4][Type 4x][Type 12]** enclosure.
 - b. Timer to automatically initiate the cleaning cycle over a 24-hour period.
 - c. Manual override of preset cleaning cycle.
 - d. Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.
 - e. For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.

- f. Flow switch bypass.
- g. Unloading signal to chiller.

2.5 SOURCE QUALITY CONTROL

- A. Perform functional tests of chillers before shipping.
- B. Factory run test each air-cooled chiller with water flowing through evaporator.
- C. Factory performance test air-cooled chillers, before shipping, in accordance with AHRI 550/590:
 - 1. Test the following conditions:
 - a. Design conditions indicated.
 - b. Reduction in capacity from design to minimum load in steps of [10][25][33]<Insert number> with condenser air at design conditions.
 - c. At [one][two][three][four][five]<Insert number> point(s) of varying part-load performance to be selected by Owner at time of test.
 - 2. Allow [Owner]<Insert entity> access to place where chillers are being tested. Notify Architect [14]<Insert number> days in advance of testing.
 - 3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
- D. Factory sound test air-cooled chillers, before shipping, in accordance with AHRI 370:
 - 1. Test the following conditions:
 - a. Design conditions indicated.
 - b. Chiller operating at calculated worst-case sound condition.
 - c. At [one][two][three][four][five]<Insert number> point(s) of varying part-load performance to be selected by Owner at time of test.
 - 2. Allow [Owner]<Insert entity> access to place where chillers are being tested. Notify Architect [14]<Insert number> days in advance of testing.
 - 3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
- E. Factory test and inspect evaporator and condenser in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- F. For chillers located indoors, rate sound power level in accordance with AHRI 575.
- G. For chillers located outdoors, rate sound power level in accordance with AHRI 370.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine chillers before installation. Reject chillers that are damaged.
- B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical

connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF AIR-COOLED, ROTARY-SCREW WATER CHILLERS

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

D. Install chillers on support structure indicated.

E. Equipment Mounting:

1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

F. Maintain manufacturer's recommended clearances for service and maintenance.

G. Charge chiller with refrigerant and fill with oil if not factory installed.

H. Install separate devices furnished by manufacturer and not factory installed.

3.3 INSTALLATION OF HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM

A. Install brush-cleaning system control panel adjacent to chiller control panel.

B. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.

C. Provide field electric power, as required, to each system control panel and electric actuated valve.

D. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.

E. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.

F. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and

control panel, with chiller in operation.

3.4 CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping," Section 232116 "Hydronic Piping Specialties," **[and] Section 232300 "Refrigerant Piping."** Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to chiller to allow service and maintenance.
- C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, **[strainer,] flexible connector,** thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, **[flexible connector,]** flow switch, thermometer, plugged tee with shutoff valve and pressure gage, **[flow meter,]** and drain connection with valve. Make connections to chiller with a **[flange][or][mechanical coupling]**.
- D. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, **[strainer,] flexible connector,** thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, **[flexible connector,]** flow switch, thermometer, plugged tee with shutoff valve and pressure gage, **[flow meter,]** and drain connection with valve. Make connections to chiller with a **[flange][or][mechanical coupling]**.
- E. Heat-Reclaim Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, **[strainer,] flexible connector,** thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, **[flexible connector,]** flow switch, thermometer, plugged tee with shutoff valve and pressure gage, **[flow meter,]** and drain connection with valve. Make connections to chiller with a **[flange][or][mechanical coupling]**.
- F. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend **[vent piping][separate vent piping for each chiller]** to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect vent to chiller pressure relief device with flexible connector and dirt leg with drain valve.
- G. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
 - 3. Verify that pumps are installed and functional.
 - 4. Verify that thermometers and gages are installed.
 - 5. Operate chiller for run-in period.
 - 6. Check bearing lubrication and oil levels.
 - 7. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
 - 8. Verify proper motor rotation.
 - 9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
 - 10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
 - 11. Verify and record performance of chiller protection devices.
 - 12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and

equipment.

- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
- C. Prepare test and inspection startup reports.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers.[**Video record the training sessions.**]

END OF SECTION 23 64 26 13

SECTION 23 64 26 16 - WATER-COOLED, ROTARY-SCREW WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, water-cooled, rotary-screw chiller - single compressor.
2. Packaged, water-cooled, rotary-screw chiller - multiple compressor.
3. Modular, housed, water-cooled rotary-screw water chiller.

B. Related Requirements:

1. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for non-structural components.
2. Section 284400 "Refrigerant Detection and Alarm" for refrigerant monitors and alarms.

1.2 DEFINITIONS

- A. COP:** Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- B. EER:** Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
- C. IPLV:** Integrated part-load value. A single-number part-load efficiency figure of merit calculated in accordance with the method defined by **AHRI 550/590 (AHRI 551/591)** and referenced to AHRI standard rating conditions.
- D. kVAR:** Kilovolt amperes reactive.
- E. kW/Ton (kW/kW):** The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in **tons (kW)** at any given set of rating conditions.
- F. NPLV:** Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated in accordance with the method defined by **AHRI 550/590 (AHRI 551/591)** and intended for operating conditions other than AHRI standard rating conditions.

1.3 ACTION SUBMITTALS

A. Product Data: For each specified system and assembly, including components and accessories.

1. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
 - a. Full load performance at **AHRI 550/590 (AHRI 551/591)** standard conditions and at conditions indicated.
 - b. Part load performance at **AHRI 550/590 (AHRI 551/591)** standard unloading conditions and at conditions indicated.

- c. Minimum evaporator fluid-flow rate.
- d. Minimum leaving evaporator-fluid temperature.
- e. Refrigerant capacity of chiller.
- f. Oil capacity of chiller.
- g. Fluid capacity of evaporator.
- h. Characteristics of safety relief valves.
- i. Fluid capacity of condenser [**and heat-reclaim condenser**] .
- j. Minimum condenser [**and heat-reclaim condenser**] fluid-flow rate.
- k. Minimum entering condenser-fluid temperature.
- l. Maximum entering condenser [**and heat-reclaim condenser**] -fluid temperature.
- m. Performance at varying capacities with constant-design, entering condenser-fluid temperature and constant-design, leaving evaporator-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in [5 deg F (3 deg C)]<Insert temperature> increments and varying capacities for different leaving evaporator-fluid temperatures from design to maximum in [1 deg F (0.5 deg C)]<Insert temperature> increments and.
- 1) Capacity Increments: Performance at different capacity increments of [10]<Insert value> percent from design to minimum capacity.
- n. Weights of individual chiller components needed for design of lifting and rigging apparatus associated with ongoing chiller service. List weight for each serviceable and removeable chiller component (such as compressor, compressor motor, water box) that weighs more than [100 pounds (45 kg)]<Insert weight> .
- o. Chiller total heat rejection to room at worst-case operating condition.
- p. Submit complete product information showing a detailed comparison of proposed products against all the requirements indicated.

B. Shop Drawings:

- 1. Include plans, elevations, sections, and attachment details.
- 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- 3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

- 1. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
- 2. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
- 3. Product Data: For energy performance.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Certificates: For certification required in "Quality Assurance" Article.
- C. Seismic Qualification Data: Certificates, for chillers, accessories, and components, from manufacturer. Submit certification that specifies equipment will withstand wind forces identified in Section 018123 "Facility Seismic and Wind Criteria" and coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- D. Source quality control reports.
- E. Field Quality Control Reports: Startup service reports.
- F. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each chiller.
- B. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 QUALITY ASSURANCE

- A. AHRI Certification: Certify chiller in accordance with **AHRI 550/590 (AHRI 551/591)** certification program.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Ship chillers from the factory fully charged with refrigerant.
- B. Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.
- C. Ship each chiller with a full charge of oil.
1. Ship oil **[factory installed in chiller][in containers separate from chiller]** .
- D. Package chiller for export shipping in totally enclosed **[crate][and][bagging]** .

1.8 WARRANTY

- A. Special Warranty: **[Manufacturer agrees][Installer agrees][Manufacturer and Installer agree]** to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
1. Components include, but are not limited to, the following:
 - a. Complete chiller, including refrigerant and oil charge.
 - b. Complete compressor and motor assembly, including refrigerant and oil charge.
 2. Warranty Coverage: Parts **[only][and labor]** .
 3. Warranty Period: **[Two][Three][Four][Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Water-cooled, rotary-screw chillers are to withstand the effects of earthquake motions. See Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified [**and the unit will be fully operational after the seismic event**] ."
 2. Component Importance Factor: [**1.5**] [**1.0**] .
 3. Requirements for Component Amplification Factor and Component Response Modification Factor: **<Insert requirements>** .
- B. Condenser-Fluid Temperature Performance:
1. Startup Condenser-Fluid Temperature: Chiller is to be capable of starting with an entering condenser-fluid temperature of [**60 deg F (16 deg C)**] [**55 deg F (13 deg C)**] [**40 deg F (4 deg C)**] **<Insert temperature>** and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
 2. Minimum Operating Condenser-Fluid Temperature: Chiller is to be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of [**65 deg F (18 deg C)**] [**60 deg F (16 deg C)**] [**55 deg F (13 deg C)**] .
 3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
- C. Site Altitude: Chiller is to be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
- D. Performance Tolerance: Comply with the following in lieu of **AHRI 550/590 (AHRI 551/591)**:
1. Allowable Capacity Tolerance: [**Zero**] **<Insert number>** percent.
 2. Allowable IPLV/NPLV Performance Tolerance: [**Zero**] **<Insert number>** percent.
- E. Rapid Restart and Loading Feature: Where indicated by individual chiller characteristics, chiller to restart and reach the defined percent of design capacity within the defined time period of a start or restart signal immediately after an electrical power interruption. Include uninterrupted power supply (UPS) integral to chiller controls to comply with this requirement.
1. Submit documentation of proposed chiller model's past performance showing a history of achieving rapid restarts and loading. [**Further demonstrate compliance through a documented factory test of at least one chiller being installed on this Project.**]
- F. AHRI Rating: Rate chiller performance in accordance with requirements in **AHRI 550/590 (AHRI 551/591)**.
- G. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration [**and ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements**] .
- H. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- I. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.

- J. Comply with NFPA 70.
- K. Comply with requirements of UL Standards & Engagement Inc., and include label by a qualified testing agency showing compliance.
- L. Operation Following Loss of Normal Power:
 - 1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system are to automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought online.
 - 2. Refer to Drawings for equipment served by back-up power systems.
 - 3. Provide means and methods required to satisfy requirement.

2.2 PACKAGED, WATER-COOLED, ROTARY-SCREW CHILLER - SINGLE COMPRESSOR

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - 1. **[Carrier Global Corporation]**
 - 2. **[Daikin Applied]**
 - 3. **[Dunham-Bush, Inc]**
 - 4. **[Trane]**
 - 5. **[WaterFurnace International, Inc.]**
 - 6. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 - 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Carrier Global Corporation]**
 - 2. **[Daikin Applied]**
 - 3. **[Dunham-Bush, Inc]**
 - 4. **[Trane]**
 - 5. **[WaterFurnace International, Inc.]**
 - 6. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
 - 7. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain packaged, water-cooled, rotary-screw single compressor chillers from single manufacturer.
- D. Description: Factory-assembled, functionally **[and run]** -tested chiller with compressor, compressor motor, compressor motor controller, lubrication system, evaporator, condenser, **[heat-reclaim condenser where indicated,]** controls, interconnecting unit piping and wiring, and indicated accessories.
 - 1. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
- E. Base: Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement **[without damage]** during a seismic event when chiller base is anchored to a field support structure.
- F. Compressor:

1. Type: Semi-hermetic, positive displacement, and oil lubricated.
 2. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
 3. Rotors: Manufacturer's standard rotor design.
 4. Seals: Seal compressor and drive assembly to prevent refrigerant leakage.
- G. Compressor Motor:
1. Cooling: Semi-hermetically sealed and cooled by refrigerant suction gas.
 2. Type: Continuous-duty, squirrel-cage, induction-type motor with energy efficiency required for performance indicated.
 3. Assembly: Factory mounted, aligned, and balanced as part of compressor-drive assembly.
 4. Capacity: Motor with sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
 5. Motor Winding Temperature Monitoring: Thermistor or RTD mounted in **[single motor winding][each of three-phase motor windings]** to monitor temperature and report information to chiller control panel.
 6. Motor Bearing Temperature Monitoring: Thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
- H. Vibration Balance: Precision balance chiller compressor and motor assembly to minimize vibration over entire operating range.
- I. Compressor and Motor Assembly Field-Service: Design chiller to make compressor and motor assembly easily accessible for field-inspection and -service.
1. Compressor's internal components are to be accessible without having to remove compressor and motor assembly from chiller.
 2. Provide lifting lugs or eyebolts attached to casing for rigging.
- J. Capacity Control: Use modulating slide-valve assemblies, port unloaders, variable-speed compressor operation, hot-gas bypass or a combination of these capacity control methods to achieve the performance indicated.
1. Maintain stable operation throughout the range of operation. Configure the chiller to achieve the most energy-efficient operation possible for the operating condition.
 2. Avoid use of hot-gas bypass if other options are available to achieve performance indicated. Apply hot-gas bypass in accordance with ASHRAE/IES 90.1 and governing codes.
 3. Operating Range: From 100 down to **[20][15][10][5][zero]<Insert number>** percent of design capacity.
 4. Condenser-Fluid Requirements over Operating Range: **[Constant-design, entering condenser-fluid temperature][Drop-in, entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) drop for each 10 percent in capacity reduction]<Insert conditions>** .
- K. Oil Lubrication System: Complete system consisting of pump if required, filtration, heater, cooler, factory-wired power connection(s), and integral controls.
1. Operation: Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions **[including chiller shutdown during a power failure]**
 2. Oil Heater: Thermostatically control and properly size oil heater to separate refrigerant and oil.
 3. Oil Cooler: **[Refrigerant][Fluid][Refrigerant- or fluid]** -cooled oil cooler. Oil cooler may be omitted if not required by chiller field application.
 4. Oil Filtration: Easily serviceable and replaceable, with means of positive isolation while servicing.
 5. Type: Chiller manufacturer standard type. **[Provide dual oil filters, one redundant.]**
 6. Filtration Efficiency: Efficiency selected by chiller manufacturer for optimum chiller performance

- and long life [, **minimum efficiency 0.5 microns**] .
- 7. Oil Level Indication: Provide positive visual indication of oil level.
- 8. Oil: Use an oil that is compatible with the refrigerant and chiller components in contact with the oil.
- 9. Oil Lubrication System Piping: Factory-install piping with isolation valves and accessories required for a complete system.
- 10. Oil Pressure Monitoring and Control: Monitoring and controls to regulate oil pressure within safe operating limits.
- 11. Oil Sump: Sufficient capacity with reserve needed for safe and reliable operation.
- 12. Pressure Testing: Factory pressure-test system to verify system has no leaks.

L. Refrigeration System:

- 1. Refrigerant Type: [**R-513A, ASHRAE 34, Class A1**][**R-513A, ASHRAE 34, Class A1; or R-515B, ASHRAE 34, Class A1; or R-1234ze, ASHRAE 34, Class A2L**]**<Insert type>** .
- 2. Refrigerant Compatibility: Chiller parts exposed to refrigerants are to be fully compatible with refrigerants, and pressure components are to be rated for refrigerant pressures.
- 3. Refrigerant Circuit: Circuit to include:
 - a. Electronic-expansion valve.
 - b. Refrigerant charging connections and valves.
 - c. Hot-gas muffler.
 - d. Compressor suction and discharge shutoff valves.
 - e. Liquid-line shutoff valves.
 - f. Replaceable-core filter-dryer.
 - g. Sight glass with moisture indicator.
 - h. Economizer.
- 4. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.
- 5. Pressure Relief Device:
 - a. Comply with requirements in ASHRAE 15 and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.
 - 1) Provide pressure relief valves for each heat exchanger.
 - 2) Dual Valves: Include dual valves for each heat exchanger with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.
- 6. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 [**and ASHRAE 147**] .
- 7. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell. [**In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell.**]

M. Evaporator:

- 1. Design: Shell-and-tube design with fluid in tubes and refrigerant surrounding tubes within shell. Evaporator shell is separate from condenser.
- 2. Code Compliance: Tested and stamped in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- 3. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless carbon-

- steel pipe.
4. Refrigerant Carryover: Design evaporator with mist eliminator or other means to prevent liquid refrigerant carryover from entering compressor.
5. Refrigerant Level Indication: Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
6. Tubes:
 - a. Individually field-replaceable from either end and without damage to tube sheets and other tubes.
 - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - c. Material: **[Copper][Copper-nickel alloy][Copper or copper-nickel alloy]<Insert material>** .
 - d. Nominal OD: **[Manufacturer's choice][3/4 inch (19 mm)][1 inch (25 mm)][3/4 or 1 inch (19 or 25 mm)]** .
 - e. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>** .
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: **[Enhanced][or][smooth]** .
7. Tube Sheets:
 - a. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 - b. Intermediate Tube Sheets: Carbon-steel plates drilled and reamed to accommodate tubes; welded to shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
8. Water Boxes: Install removable water boxes arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - a. Attachment: Bolt and gasket water boxes to end tube sheets to provide a watertight seal.
 - b. Material: Carbon-steel construction.
 - c. Type: **[Standard][or][Marine]** type for water box with piping connections. Standard type for water boxes without piping connections.
 - d. Lifting Provisions: Provide water boxes **[and marine water-box covers]** with lifting lugs or eyebolts.
 - e. Hinged Water Boxes: Factory install hinges on one side of water box for ease of opening and to support the weight of water box when opened.
 - f. Hinged Marine Water-Box Covers: Factory install hinges on one side of cover for ease of opening and to support the weight of cover when opened.
 - g. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]** .
 - h. Fluid-Temperature Monitoring: Thermistor or RTD temperature sensor factory installed in each nozzle to monitor fluid temperature and report information to chiller control panel.
 - i. Drain Connections: Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension>** NPT connection and threaded plug at low point of water box.
 - j. Vent Connections: Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension>** NPT connection and threaded plug at high point of water box.
9. Additional Corrosion Protection:

- a. Anodes: Factory install easily replaceable electrolytic corrosion-inhibitor **[zinc][or][magnesium]** anodes inside of water boxes.
- b. Corrosion-Resistant Finish: Coat wetted surfaces with a corrosion-resistant finish.

N. Condenser:

- 1. Design: Shell-and-tube design with fluid in tubes and refrigerant surrounding tubes within shell. Condenser shell is separate from the evaporator.
- 2. Code Compliance: Tested and stamped in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- 3. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
- 4. Hot-Gas Dispersion: Design and factory install baffle plates or other means to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
- 5. Refrigerant Visual Indicator: Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.
- 6. Tubes:
 - a. Individually field-replaceable from either end and without damage to tube sheets and other tubes.
 - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - c. Material: **[Copper][Copper-nickel alloy][Copper or copper-nickel alloy]<Insert material>** .
 - d. Nominal OD: **[Manufacturer's choice][3/4 inch (19 mm)][1 inch (25 mm)][3/4 or 1 inch (19 or 25 mm)]** .
 - e. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>** .
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: **[Enhanced][or][smooth]** .
- 7. Tube Sheets:
 - a. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 - b. Intermediate Tube Sheets: Carbon-steel plates drilled and reamed to accommodate tubes; welded to shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
- 8. Water Boxes: Install removable water boxes arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - a. Attachment: Bolt and gasket water boxes to end tube sheets to provide a watertight seal.
 - b. Material: Carbon-steel construction.
 - c. Type: **[Standard][or][marine]** -type water boxes for water boxes with piping connections. Standard type water boxes for water boxes without piping connections.
 - d. Lifting Provisions: Provide water boxes **[and marine water-box covers]** with lifting lugs or eyebolts.
 - e. Hinged Water Boxes: Install hinges on one side of water box for ease of opening and to support the weight of water box when opened.
 - f. Hinged Marine Water-Box Covers: Install hinges on one side of cover for ease of opening and to support the weight of cover when opened.
 - g. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]** .
 - h. Fluid-Temperature Monitoring: Thermistor or RTD temperature sensor factory installed in

- each nozzle to monitor fluid temperature and report information to chiller control panel.
 - i. Drain Connections: Fit each water box with [3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension> NPT connection and threaded plug at low point of water box.
 - j. Vent Connections: Fit each water box with [3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension> NPT connection and threaded plug at high point of water box.
 9. Additional Corrosion Protection:
 - a. Anodes: Factory install easily replaceable electrolytic corrosion-inhibitor [zinc][or][magnesium] anodes inside of water boxes.
 - b. Corrosion-Resistant Finish: Coat wetted surfaces with a corrosion-resistant finish.
- O. Heat-Reclaim Condenser:
 1. Design: Shell-and-tube design with fluid in tubes and refrigerant surrounding tubes within shell. Heat-reclaim condenser shell is separate from evaporator.
 2. Code Compliance: Tested and stamped in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 3. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
 4. Hot-Gas Dispersion: Design and factory-install baffle plates or other means to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
 5. Tubes:
 - a. Individually field-replaceable from either end and without damage to tube sheets and other tubes.
 - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - c. Material: [Copper][Copper-nickel alloy][Copper or copper-nickel alloy]<Insert material> .
 - d. Nominal OD: [Manufacturer's choice][3/4 inch (19 mm)][1 inch (25 mm)][3/4 or 1 inch (19 or 25 mm)] .
 - e. Minimum Wall Thickness: [Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension> .
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: [Enhanced][or][smooth] .
 6. Tube Sheets:
 - a. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 - b. Intermediate Tube Sheets: Carbon-steel plates drilled and reamed to accommodate tubes; welded to shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
 7. Water Boxes: Install removable water boxes arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - a. Attachment: Bolt and gasket water boxes to end tube sheets to provide a watertight seal.
 - b. Material: Carbon-steel construction.
 - c. Type: [Standard][or][Marine] type water boxes for water boxes with piping connections. Standard type water boxes for water boxes without piping connections.
 - d. Lifting Provisions: Provide water boxes [and marine water-box covers] with lifting lugs or

- eyebolts.
 - e. Hinged Water Boxes: Install hinges on one side of water box for ease of opening and to support the weight of water box when opened.
 - f. Hinged Marine Water-Box Covers: Install hinges on one side of cover for ease of opening and to support the weight of cover when opened.
 - g. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]** .
 - h. Fluid-Temperature Monitoring: Thermistor or RTD temperature sensor factory installed in each nozzle to monitor fluid temperature and report information to chiller control panel.
 - i. Drain Connections: Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension>** NPT connection and threaded plug at low point of water box.
 - j. Vent Connections: Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension>** NPT connection and threaded plug at high point of water box.
8. Additional Corrosion Protection:
- a. Anodes: Factory install easily replaceable electrolytic corrosion-inhibitor **[zinc][or][magnesium]** anodes inside of water boxes.
 - b. Corrosion-Resistant Finish: Coat wetted surfaces with a corrosion-resistant finish.
- P. Electrical Power:
- 1. Factory installed and wired, and functionally tested at factory before shipment.
 - 2. Single-Point Field-Power Connections: Provide chiller with single-point, field-power connection to **[wiring lugs][NEMA BS 31047, heavy-duty, fused disconnect switch][NEMA BS 31047, heavy-duty, nonfused disconnect switch][UL 489, instantaneous-trip circuit breaker]** .
 - a. Enclosure: NEMA 250, **[Type 1]<Insert type>** .
 - b. Withstand Rating: Minimum withstand rating is to be as required by electrical power distribution system, but not less than **[42,000][65,000][100,000]<Insert value>** A.
 - c. Electrical Power for Controls: Factory-install a control-circuit transformer with primary and secondary side fuses for chillers with single-point, field-power connection.
 - 3. Field-Power Connections: Provide chiller with manufacturer's standard multiple field-power connections to **[wiring lugs][NEMA BS 31047, heavy-duty, fused disconnect switch][NEMA BS 31047, heavy-duty, nonfused disconnect switch][UL 489, instantaneous-trip circuit breaker]** .
 - a. Enclosure: NEMA 250, **[Type 1]<Insert type>** .
 - b. Withstand Rating: Minimum withstand rating is to be as required by electrical power distribution system, but not less than **[42,000][65,000][100,000]<Insert value>** A.
 - c. Electrical Power for Controls: Dedicated single-point, field-power connection to chiller controls.
 - 4. Branch Circuits: Provide branch power circuit to each motor, electric heater, dedicated electrical load, and controls **[with disconnect switch or circuit breaker]** with same withstand rating to match main disconnecting means.
 - a. Factory-install a NEMA ICS 2-rated motor controller, hand-off-auto switch, and overcurrent protection for each auxiliary motor.
 - 5. Terminal Blocks: Terminal blocks with numbered **[and color-coded]** wiring to match wiring diagram. Include spare wiring terminal block for connection to external controls or equipment.

6. Electrical Power Wiring Raceways: Factory-install electrical power wiring outside of enclosures in metal raceways. Terminate connections to each motor and heater with not more than [24-inch (610-mm)]<Insert dimension> length of [liquidtight][or][flexible] conduit.
 7. Power Factor Correction: Factory install and wire a capacitor bank for the purpose of power factor correction to [0.95]<Insert value> at all operating conditions.
 - a. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
 - b. Capacitors are to be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAR ratings are to be indicated and not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
 - c. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within one minute after de-energizing.
 - d. Provide a ground terminal and a terminal block or individual connectors for phase connection.
- Q. Constant-Speed Motor Controllers: Factory-furnished and [field] installed for use with constant-speed motors.
1. Enclosure: NEMA 250, [Type 1]<Insert type> , with hinged full-front access door [with lock and key or padlock and key] .
 2. Control Circuit: Power obtained from [integral control power transformer]<Insert source of control power> with enough capacity to operate connected control devices.
 3. Overload Relays: Size overload relays in accordance with UL 1995 or be an integral component of chiller control microprocessor.
 4. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.
 5. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, [closed-][or][open-] transition.
 6. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
 - a. Surge suppressor in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 - b. Visual indication of motor and control status, including the following conditions:
 - 1) Controller on.
 - 2) Overload trip.
 - 3) Loss of phase.
 - 4) Starter fault.
 7. Accessories: Devices are to be factory installed in controller enclosure unless otherwise indicated.
 - a. Disconnect Type: Externally operated [, door-interlocked] disconnect; [NEMA BS 31047, heavy-duty, fused disconnect switch][NEMA BS 31047, heavy-duty, nonfused disconnect switch][UL 489, instantaneous-trip circuit breaker] . Minimum withstand rating is to be as required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
 - b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
 - c. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
 - d. Control Relays: Time-delay relays.
 - e. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
 - f. Number-of-Starts Counter: Numerical readout on face of enclosure.

- g. Meters: Panel type, [2-1/2 inches (64 mm)][4-1/4 inches (108 mm)] with [90][120][270] - degree scale and [1][2] percent accuracy. Where indicated, provide transfer device with an off position. Meters are to indicate the following:
 - 1) Ammeter: Output current for each phase, with current sensors rated to suit application.
 - 2) Voltmeter: Output voltage for each phase.
 - 3) Frequency Meter: Output frequency.
 - 4) Real-time clock with current time and date.
 - 5) Total run time.
 - h. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
 - 1) Selectable, digital display of the following:
 - a) Phase Currents, Each Phase: Within [1]<Insert value> percent.
 - b) Phase-to-Phase Voltages, Three Phase: Within [1]<Insert value> percent.
 - c) Phase-to-Neutral Voltages, Three Phase: Within [1]<Insert value> percent.
 - d) Three-Phase Real Power: Within [2]<Insert value> percent.
 - e) Three-Phase Reactive Power: Within [2]<Insert value> percent.
 - f) Power Factor: Within [2]<Insert value> percent.
 - g) Frequency: Within [0.5]<Insert value> percent.
 - h) Integrated Demand with Demand Interval: Selectable from [5 to 60]<Insert range> Minutes: Within [2]<Insert value> percent.
 - i) Accumulated Energy, in Megawatt Hours (Joules): Within [2]<Insert value> percent; stored values unaffected by power outages for up to [72]<Insert value> hours.
 - 2) Mounting: Display and control unit flush or semirecessed in instrument compartment door.
 - i. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
 - j. Power Protection: Chiller is to shut down within [six]<Insert value> cycles of power interruption.
- R. Variable-Frequency Controllers: Factory-furnished and installed for use with variable-speed motors.
- 1. Factory mount motor controller and wire chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
 - a. Where indicated on the Drawings or in the "Capacities and Characteristics" paragraphs, install a variable-frequency controller for each variable-speed motor to allow operation of one motor with the other motor disconnected and isolated for service.
 - 2. Design: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
 - 3. Enclosure: Unit mounted, NEMA 250, [Type 1]<Insert type> , with hinged full-front access door with lock and key.
 - 4. Integral Disconnecting Means: [Door-interlocked,] UL 489, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating is to be as required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
 - 5. Technology: Pulse-width-modulated output suitable for constant or variable torque loads.
 - 6. Output Rating: Three-phase; with voltage proportional to frequency throughout voltage range.
 - 7. Operating Requirements:

- a. Input AC Voltage Tolerance: **[Chiller voltage indicated, plus 10 percent]<Insert voltage and tolerance>** .
 - b. Input Frequency: Tolerance of 60 Hz, plus or minus **[2]<Insert value>** Hz.
 - c. Capable of driving full load, without derating, under the following conditions:
 - 1) Ambient Temperature: **[0 to 40]<Insert temperature range>** deg C.
 - 2) Relative Humidity: Up to **[90][95]** percent (noncondensing).
 - 3) Altitude: **[3300 ft. (1005 m)][6600 ft. (2010 m)]** .
 - d. Minimum Efficiency: **[96]<Insert value>** percent at 60 Hz, full load.
 - e. Minimum Displacement Primary-Side Power Factor: **[98]<Insert value>** percent.
 - f. Overload Capability: **[1.05]<Insert value>** times the full-load current for seven seconds.
 - g. Starting Torque: As required by compressor-drive assembly.
 - h. Speed Regulation: Within **[1]<Insert value>** percent.
 - i. Isolated Control Interface: To allow controller to follow control signal over a **[5:1][10:1]<Insert value>** speed range.
 - j. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller is not to operate continuously.
 - k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
8. Internal Adjustability Capabilities:
- a. Minimum Output Frequency: **[6]<Insert value>** Hz.
 - b. Maximum Output Frequency: **[60]<Insert value>** Hz.
 - c. Acceleration: **[2]<Insert value>** to **[60]<Insert value>** seconds.
 - d. Deceleration: Zero to **[60]<Insert value>** seconds.
 - e. Current Limit: **[30]<Insert value>** to 100 percent of maximum rating.
9. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions is to not result in component failure or the need for replacement:
- a. Overtemperature.
 - b. Short circuit at controller output.
 - c. Ground fault at controller output. Variable-frequency controller is to be able to start a grounded motor.
 - d. Open circuit at controller output.
 - e. Input undervoltage.
 - f. Input overvoltage.
 - g. Loss of input-phase.
 - h. Reverse phase.
 - i. AC line switching transients.
 - j. Instantaneous overload, line to line or line to ground.
 - k. Sustained overload exceeding 100 percent of controller rated current.
 - l. Starting a rotating motor.
10. Motor Protection: Controller to protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
11. Automatic Reset and Restart: Capable of **[three]<Insert number>** restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller is to be capable of automatic restart on phase-loss, and overvoltage and undervoltage trips.
12. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:

- a. Power on.
 - b. Run.
 - c. Overvoltage.
 - d. Line fault.
 - e. Overcurrent.
 - f. External fault.
 - g. Motor speed (percent).
 - h. Fault or alarm status (code).
 - i. Motor output voltage.
 - j. Input kilovolt amperes.
 - k. Total power factor.
 - l. Input kilowatts.
 - m. Input kilowatt-hours.
 - n. Three-phase input voltage.
 - o. Three-phase output voltage.
 - p. Three-phase input current.
 - q. Three-phase output current.
 - r. Three-phase input voltage THD.
 - s. Three-phase input current THD.
 - t. Output frequency (Hertz).
 - u. Elapsed operating time (hours).
 - v. Diagnostic and service parameters.
13. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.
14. Control Signal Interface:
- a. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and **[six]<Insert value>** programmable digital inputs.
 - b. Manufacturer has option to incorporate control signal interface into chiller control panel.
15. Active Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to **[5]<Insert number>** percent.
- a. Limit variable-frequency controller voltage Total Harmonic Distortion (THD) and current Total Demand Distortion (TDD) to comply with IEEE 519 requirements.

S. Controls:

- 1. Standalone and microprocessor based with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
- 2. Enclosure: Unit mounted, NEMA 250, **[Type 1][Type 3R]<Insert type>**, hinged or lockable.
- 3. Control Wiring Raceways: Factory-install control wiring outside of enclosures in metal raceway. Terminate connections to each control device with not more than a **[24-inch (610-mm)]<Insert dimension>** length of **[liquidtight][or][flexible]** conduit.
- 4. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
 - a. Date and time.
 - b. Operating or alarm status.
 - c. Fault history with not less than last **[10][5]<Insert value>** faults displayed.
 - d. Set points of controllable parameters.
 - e. Trend data.
 - f. Operating hours.
 - g. Number of chiller starts.

- h. Outdoor-air temperature or space temperature if required for chilled-water reset.
 - i. Temperature and pressure of operating set points.
 - j. Entering- and leaving-fluid temperatures of evaporator and condenser.
 - k. Difference in fluid temperatures of evaporator and condenser.
 - l. Refrigerant pressures in evaporator and condenser.
 - m. Refrigerant saturation temperature in evaporator and condenser.
 - n. Pump status.
 - o. Antirecycling timer status.
 - p. Percent of maximum motor amperage.
 - q. Current-limit set point.
 - r. Compressor bearing temperature.
 - s. Motor bearing temperature.
 - t. Motor winding temperature.
 - u. Oil temperature.
 - v. Oil discharge pressure.
 - w. Phase current.
 - x. Percent of motor rated load amperes.
 - y. Phase voltage.
 - z. Demand power (kilowatts).
 - aa. Energy use (kilowatt-hours).
 - bb. Power factor.
5. Control Functions:
- a. Manual or automatic startup and shutdown time schedule.
 - b. Entering and leaving chilled-water temperatures, control set points, and motor load limits.
 - c. Evaporator Leaving Fluid Temperature Reset: Reset leaving evaporator-fluid temperature based on **[return-fluid temperature][outdoor-air temperature][space temperature][remote terminal unit control valve position]<Insert reset variable>** temperature.
 - d. Current limit and demand limit.
 - e. Condenser-fluid temperature.
 - f. External chiller emergency stop.
 - g. Antirecycling timer.
 - h. Variable evaporator flow.
 - i. Thermal storage.
 - j. Dual mode operation with thermal storage.
 - k. Heat pump.
 - l. Heat reclaim.
6. Manually Reset Safety Controls: The following conditions are to shut down chiller and require manual reset:
- a. Low evaporator refrigerant pressure or temperature.
 - b. High condenser pressure.
 - c. Low evaporator fluid temperature.
 - d. Low oil differential pressure.
 - e. High or low oil pressure.
 - f. High oil temperature.
 - g. High compressor-discharge temperature.
 - h. Loss of condenser-fluid flow.
 - i. Loss of evaporator-fluid flow.
 - j. Motor overcurrent.
 - k. Motor overvoltage.
 - l. Motor undervoltage.

- m. Motor phase reversal.
 - n. Motor phase failure.
 - o. Sensor- or detection-circuit fault.
 - p. Processor communication loss.
 - q. Motor controller fault.
 - r. Extended compressor surge.
- 7. Trending: Capability to trend analog data of up to **[three][five]<Insert value>** parameters simultaneously over an adjustable period and frequency of polling.
- 8. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
- 9. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
- 10. Communication Port: USB 2.0 port or higher, capable of connecting to a notebook computer **[tablet][smart phone][or][printer]** .
- 11. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller operation and alarms.
 - a. Hardwired Points:
 - 1) Monitoring: On-off status, **[common trouble alarm][electrical power demand (kilowatts)][electrical power consumption (kilowatt-hours)][power factor]<Insert monitoring point>** .
 - 2) Control: On-off operation, **[leaving evaporator-fluid temperature set-point adjustment][electrical power demand limit]<Insert control point>** .
 - b. Serial Communication Interface: **[ASHRAE 135 (BACnet) IP][ASHRAE 135 (BACnet) MS/TP][LonTalk][Modbus TCP/IP][Modbus RTU][Industry-accepted, open-protocol]<Insert type of interface>** communication interface with the DDC system for HVAC is to enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel are to be available through the DDC system for HVAC.
- T. Insulation:
 - 1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C534/C534M, Type I for tubular materials and Type II for sheet materials.
 - 2. Minimum Thickness: **[3/4 inch (19 mm)][1-1/2 inches (38 mm)]<Insert dimension>** .
 - 3. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
 - 4. General Requirements for Factory-Applied Insulation:
 - a. Before insulating steel surfaces, prepare surfaces for paint.
 - b. Prime and paint steel surfaces to be insulated as indicated for other painted components.
 - c. Do not insulate unpainted steel surfaces.
 - d. Seal seams and joints to provide a vapor barrier.
 - e. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
 - f. Manufacturer has option to factory or field insulate chiller components installed in multiple pieces to reduce potential for damage during installation.
 - g. Manufacturer has option to factory or field insulate water boxes and nozzles to reduce potential for damage during installation.
 - 5. Field-Applied Insulation:



- a. Chiller components that require factory-applied insulation and are not factory insulated are to be field insulated to comply with requirements indicated.
 - b. Chiller manufacturer is responsible for all chiller factory-applied insulation whether factory or field installed, to ensure chiller manufacturer is the single point of responsibility for chillers.
 - c. Chiller manufacturer factory-authorized service representative to instruct, supervise, and approve installation of field-applied insulation and paint.
 - d. After field-applied insulation is complete, paint insulation to match factory-applied finish.
6. Insulation on Cold Surfaces: Factory-apply insulation over cold surfaces of chiller capable of forming condensation. Components are to include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, compressor motor, and auxiliary piping.
7. Insulation on Hot Surfaces: For applications that use chillers to supply heating, factory-apply insulation over hot surfaces of chiller for thermal performance and personnel safety. Components are to include, but not be limited to, [**evaporator,**] condenser [, **heat-reclaim condenser,**] shell and end tube sheets, water boxes including nozzles, [**refrigerant suction pipe from evaporator to compressor,**] refrigerant discharge pipe from compressor to condenser, hot surfaces of compressor, compressor motor and auxiliary piping.

U. Finish:

1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
 - a. Primer: Provide at least one coat of primer with a total dry film thickness of at least [2 mils (0.05 mm)]<Insert thickness> .
 - b. Paint Type: Provide at least two finish coats of [alkyd-modified, vinyl enamel][epoxy][polyurethane][manufacturer's standard coating] .
 - c. Paint Thickness: Total dry film thickness of at least [4 mils (0.10 mm)]<Insert thickness> .
 - d. Insulated Surfaces:
 - 1) Paint surfaces that are to be insulated before applying the insulation.
 - 2) Paint installed insulation to match adjacent uninsulated surfaces.
 - e. Finish Coat Color: Color of finish coat to be [manufacturer's standard][custom color selected by Architect]<Insert color description> .
2. Provide Owner with the following:
 - a. Closeout Submittal Data: Submit paint manufacturer and paint product details for Owner to procure matching paint in the future.
 - b. Spare Paint: Turn over to Owner a [one quart]<Insert size> container of paint that was used in application of finish coat to use in touchup applications at Project closeout. Properly label container for ease of future reference.

V. Accessories:

1. Flow Switches: If required for chiller operation and not factory installed, chiller manufacturer to furnish flow switches for field-mounting with installation instructions.
 - a. Paddle Flow Switches:
 - 1) Type: Vane operated to actuate a double-pole, double-throw switch with one pole

- field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
 - 2) Pressure Rating: Pressure rating equal to not less than pressure rating of heat exchanger.
 - 3) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of **[10 A at 120 V ac]<Insert rating>** .
 - 4) Enclosure: House switch in a NEMA 250, **[Type 4]<Insert type>** enclosure constructed of die-cast aluminum.
 - 5) Construction: Construct body and wetted parts of Type 316 stainless steel.
 - 6) Vane: Vane length to suit installation.
 - b. Pressure Differential Switches:
 - 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
 - 2) Performance: Switch is to withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
 - 3) Set Point: Screw type, field adjustable.
 - 4) Electrical Connections: Internally mounted screw-type terminal blocks.
 - 5) Switch Enclosure: NEMA 250, **[Type 4]<Insert type>** .
 - 6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
 - c. Thermal Dispersion Type Flow Sensors/Switches: Chiller manufacturer standard offering.
 - 1) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
 - 2) Factory calibrated for Project-specific application.
2. Vibration Isolation: Chiller manufacturer to furnish chillers with vibration isolation and installation instructions for field-mounting.
 - a. Neoprene Pads:
 - 1) Two layers of **0.375-inch- (10-mm-)** thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gauge, stainless steel plate.
 - 2) Fabricate pads from 40- to 50-durometer neoprene.
 - 3) Provide stainless steel square bearing plate to load the pad uniformly between **20 and 40 psig (138 and 276 kPa)** with a **0.12- to 0.16-inch (3- to 4-mm)** deflection.
3. Sound Barriers:
 - a. Furnish removable and reusable sound-barrier covers over the compressor housing, motor, compressor suction and discharge piping, and other components as required to achieve sound performance indicated.
 - b. Design sound-barrier covers for repeated installation and removal without use of tape, caulk, and special tools.
 - c. Inner and outer surfaces of cover to consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
 - d. Double sew and lock stitch covers with edges folded and sewn so no raw cut edges are exposed.
 - e. Form covers around control devices, gauges, conduit, piping, and supports without degrading sound-barrier performance.
 - f. Continuously lap all exposed joints and seams at least **2 inches (50 mm)** for better sound

- containment.
- g. Permanently label each section of sound-barrier cover to indicate its location, description, size, and number sequence. Affix a sound-barrier installation diagram on chiller in an easily visible location.
- h. Randomly place stainless steel quilting pins to prevent covers from shifting and sagging.

W. Capacities and Characteristics:

1. Capacity: **<Insert tons (kW)>** .
2. Full-Load Efficiency:
 - a. COP: **<Insert value>** .
 - b. EER: **<Insert value>** .
 - c. Power Input/Cooling Output: **<Insert kW/ton (kW/kW)>** .
 - d. Comply with FEMP.
3. Part-Load Efficiency:
 - a. IPLV: **<Insert value>** .
 - b. NPLV: **<Insert value>** .
 - c. Comply with FEMP.
4. Evaporator:
 - a. Pressure Rating: **<Insert psig (kPa)>** .
 - b. Number of Passes: **[One][Two][Three][Four]** .
 - c. Fluid Type: **[Water]<Insert fluid type>** .
 - d. Design Fluid Flow Rate: **<Insert gpm (L/s)>** .
 - e. Minimum Fluid Flow Rate: **<Insert gpm (L/s)>** .
 - f. Entering-Fluid Temperature: **<Insert deg F (deg C)>** .
 - g. Leaving-Fluid Temperature: **<Insert deg F (deg C)>** .
 - h. Fluid Pressure Drop: **<Insert feet of head (kPa)>** .
 - i. Fluid Velocity: **<Insert fps (m/s)>** .
 - j. Fouling Factor: **[0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert value>** .
5. Condenser:
 - a. Pressure Rating: **<Insert psig (kPa)>** .
 - b. Number of Passes: **[One][Two][Three][Four]** .
 - c. Fluid Type: **[Water]<Insert fluid type>** .
 - d. Design Fluid Flow Rate: **<Insert gpm (L/s)>** .
 - e. Minimum Fluid Flow Rate: **<Insert gpm (L/s)>** .
 - f. Entering-Fluid Temperature: **<Insert deg F (deg C)>** .
 - g. Leaving-Fluid Temperature: **<Insert deg F (deg C)>** .
 - h. Fluid Pressure Drop: **<Insert feet of head (kPa)>** .
 - i. Fluid Velocity: **<Insert fps (m/s)>** .
 - j. Fouling Factor: **[0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert value>** .
6. Heat-Reclaim Condenser:

- a. Pressure Rating: **<Insert psig (kPa)>** .
 - b. Number of Passes: **[One][Two][Three]** .
 - c. Fluid Type: **[Water]<Insert fluid type>** .
 - d. Design Fluid Flow Rate: **<Insert gpm (L/s)>** .
 - e. Minimum Fluid Flow Rate: **<Insert gpm (L/s)>** .
 - f. Entering-Fluid Temperature: **<Insert deg F (deg C)>** .
 - g. Leaving-Fluid Temperature: **<Insert deg F (deg C)>** .
 - h. Fluid Pressure Drop: **<Insert feet of head (kPa)>** .
 - i. Fluid Velocity: **<Insert fps (m/s)>** .
 - j. Fouling Factor: **[0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)]<Insert value>** .
7. Compressor:
 - a. Rated Load Amperes: **<Insert value>** .
 - b. Locked-Rotor Amperes: **<Insert value>** .
8. Packaged Chiller Electrical Requirements:
 - a. Power Input: **<Insert kilowatts>** .
 - b. Power Factor: **[0.95]<Insert value>** .
 - c. Minimum Circuit Ampacity: **<Insert value>** .
 - d. Maximum Overcurrent Protection Device: **<Insert amperage>** .
 - e. Volts: **[208][240][480][600]<Insert value>** V ac.
 - f. Phase: Three.
 - g. Hertz: 60.
9. Chiller Control Electrical Requirements:
 - a. Power Connections: **[Fed through integral transformer][Separate field-power connection]** .
 - b. Power Input: **<Insert number>** kW.
 - c. Minimum Circuit Ampacity: **<Insert number>** A.
 - d. Maximum Overcurrent Protection Device: **<Insert number>** A.
 - e. Volts: **[120]<Insert number>** V ac.
 - f. Phase: Single.
 - g. Hertz: 60.
10. Noise Rating: **[85]<Insert dBA>** sound power level when measured in accordance with AHRI 575. Provide factory-installed sound treatment if necessary to achieve the performance indicated.
11. Rapid Restart and Loading Feature: Chiller to start and reach **[100]<Insert value>** percent of design capacity within **[160 seconds]<Insert seconds>** of a start signal or restart signal after electrical power interruption.

2.3 PACKAGED, WATER-COOLED, ROTARY-SCREW CHILLER - MULTIPLE COMPRESSOR

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 1. **[Carrier Global Corporation]**
 2. **[Dunham-Bush, Inc]**
 3. **[Trane]**



4. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 5. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Carrier Global Corporation]
 2. [Dunham-Bush, Inc]
 3. [Trane]
 4. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 5. <Insert manufacturer's name>
- C. Source Limitations: Obtain packaged, water-cooled, rotary-screw multiple-compressor chillers from single manufacturer.
- D. Description: Factory-assembled, functionally [**and run-**] tested chiller with compressors, compressor motors and motor controllers, evaporator, condenser where indicated, [**heat-reclaim condenser where indicated,**] electrical power, controls, and indicated accessories.
1. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
- E. Base: Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement [**without damage**] during a seismic event when chiller base is anchored to a field support structure.
- F. Compressors: Positive displacement, semi-hermetically sealed and oil lubricated.
1. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
 2. Rotors: Manufacturer's standard rotor design.
 3. Seals: Seal compressor and drive assembly to prevent refrigerant leakage.
- G. Compressor Motors:
1. Cooling: Semi-hermetically sealed and cooled by refrigerant suction gas.
 2. Type: Continuous-duty, squirrel-cage, induction-type motor with energy efficiency required for performance indicated.
 3. Assembly: Factory mounted, aligned, and balanced as part of compressor-drive assembly.
 4. Capacity: Motors with sufficient capacity to drive compressors throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
 5. Motor Winding Temperature Monitoring: Thermistor or RTD mounted in [**single motor winding**][**each of three-phase motor windings**] to monitor temperature and report information to chiller control panel.
 6. Motor Bearing Temperature Monitoring: Thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
- H. Vibration Balance: Precision balance chiller compressor and motor assembly to minimize vibration over entire operating range.
- I. Compressor and Motor Assembly Field-Service: Design chiller to make compressor and motor assembly easily accessible for field inspection and service.
1. Compressor's internal components are to be accessible without having to remove compressor and motor assembly from chiller.
 2. Provide lifting lugs or eyebolts attached to casing for rigging.

- J. Capacity Control: Use on-off compressor cycling, modulating slide-valve assemblies, port unloaders, variable-speed compressor operation, hot-gas bypass, or a combination of these capacity control methods to achieve the performance indicated.
1. Maintain stable operation throughout the range of operation. Configure the chiller to achieve the most energy-efficient operation possible for the operating condition.
 2. Operating Range: From 100 down to **[20][15][10][5][zero]<Insert number>** percent of design capacity.
 3. Condenser-Fluid Requirements over Operating Range: **[Constant-design, entering condenser-fluid temperature][Drop-in, entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) drop for each 10 percent in capacity reduction]<Insert conditions>** .
- K. Oil Lubrication System: Complete system consisting of pump if required, filtration, heater, cooler, factory-wired power connection(s), and integral controls.
1. Operation: Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions **[including chiller shutdown during a power failure]** .
 2. Oil Heater: Thermostatically control and properly size oil heater to separate refrigerant and oil.
 3. Oil Cooler: **[Refrigerant][Fluid][Refrigerant- or fluid]** -cooled oil cooler. Oil cooler may be omitted if not required by chiller field application.
 4. Oil Filtration: Easily serviceable and replaceable, with means of positive isolation while servicing.
 - a. Type: Chiller manufacturer standard type. **[Provide dual oil filters, one redundant, per refrigerant circuit]** .
 - b. Filtration Efficiency: Efficiency selected by chiller manufacturer for optimum chiller performance and long life **[, minimum efficiency 0.5 microns]** .
 5. Oil Level Indication: Provide positive visual indication of oil level.
 6. Oil: Use an oil that is compatible with the refrigerant and chiller components in contact with the oil.
 7. Oil Lubrication System Piping: Factory-install piping with isolation valves and accessories required for a complete system.
 8. Oil Pressure Monitoring and Control: Monitoring and controls to regulate oil pressure within safe operating limits.
 9. Oil Sump: Sufficient capacity with reserve needed for safe and reliable operation.
 10. Pressure Testing: Factory pressure-test system to verify system has no leaks.
- L. Refrigeration Systems:
1. Refrigerant Type: **[R-513A, ASHRAE 34 Safety Group A1]<Insert type>** .
 2. Refrigerant Compatibility: Chiller parts exposed to refrigerants are to be fully compatible with refrigerants, and pressure components are to be rated for refrigerant pressures.
 3. Refrigerant Circuit: Each circuit to include:
 - a. Electronic-expansion valve.
 - b. Refrigerant charging connections and valves.
 - c. Hot-gas muffler.
 - d. Compressor suction and discharge shutoff valves.
 - e. Liquid-line shutoff valves.
 - f. Oil filter.
 - g. Replaceable-core filter-dryer.
 - h. Sight glass with moisture indicator.
 - i. Economizer.
 4. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying

- performance requirements indicated.
5. Pressure Relief Device:
 - a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.
 - 1) Provide pressure relief valves for each heat exchanger.
 - 2) Dual Valves: Include dual valves for each heat exchanger with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.
6. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell. [**In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell.**]
7. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 [**and ASHRAE 147**] .

M. Evaporators:

1. Design: Shell-and-tube design with fluid in tubes and refrigerant surrounding tubes within shell. Evaporator shell is separate from condenser.
2. Code Compliance: Tested and stamped in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless carbon-steel pipe.
4. Refrigerant Carryover: Design evaporator with mist eliminator or other means to prevent liquid refrigerant carryover from entering compressor.
5. Refrigerant Level Indication: Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
6. Tubes:
 - a. Individually field-replaceable from either end and without damage to tube sheets and other tubes.
 - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - c. Material: [**Copper**][**Copper-nickel alloy**][**Copper or copper-nickel alloy**]**<Insert material>** .
 - d. Nominal OD: [**Manufacturer's choice**][**3/4 inch (19 mm)**][**1 inch (25 mm)**][**3/4 or 1 inch (19 or 25 mm)**] .
 - e. Minimum Wall Thickness: [**Manufacturer's choice**][**0.025 inch (0.6 mm)**][**0.028 inch (0.7 mm)**][**0.035 inch (0.9 mm)**]**<Insert dimension>** .
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: [**Enhanced**][**or**][**smooth**] .
7. Tube Sheets:
 - a. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 - b. Intermediate Tube Sheets: Carbon-steel plates drilled and reamed to accommodate tubes; welded to shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

8. Water Boxes: Install removable water boxes arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - a. Attachment: Bolt and gasket water boxes to end tube sheets to provide a watertight seal.
 - b. Material: Carbon-steel construction.
 - c. Type: **[Standard][or][Marine]** type for water box with piping connections. Standard type for water boxes without piping connections.
 - d. Lifting Provisions: Provide water boxes **[and marine water-box covers]** with lifting lugs or eyebolts.
 - e. Hinged Water Boxes: Factory install hinges on one side of water box for ease of opening and to support the weight of water box when opened.
 - f. Hinged Marine Water-Box Covers: Factory install hinges on one side of cover for ease of opening and to support the weight of cover when opened.
 - g. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]** .
 - h. Fluid-Temperature Monitoring: Thermistor or RTD temperature sensor factory installed in each nozzle to monitor fluid temperature and report information to chiller control panel.
 - i. Drain Connections: Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension>** NPT connection and threaded plug at low point of water box.
 - j. Vent Connections: Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension>** NPT connection and threaded plug at high point of water box.
9. Additional Corrosion Protection:
 - a. Anodes: Factory install easily replaceable electrolytic corrosion-inhibitor **[zinc][or][magnesium]** anodes inside of water boxes.
 - b. Corrosion-Resistant Finish: Coat wetted surfaces with a corrosion-resistant finish.

N. Condensers:

1. Design: Shell-and-tube design with fluid in tubes and refrigerant surrounding tubes within shell. Condenser shell is separate from the evaporator.
2. Code Compliance: Tested and stamped in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
4. Hot-Gas Dispersion: Design and factory install baffle plates or other means to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
5. Refrigerant Visual Indicator: Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.
6. Tubes:
 - a. Individually field-replaceable from either end and without damage to tube sheets and other tubes.
 - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - c. Material: **[Copper][Copper-nickel alloy][Copper or copper-nickel alloy]<Insert material>** .
 - d. Nominal OD: **[Manufacturer's choice][3/4 inch (19 mm)][1 inch (25 mm)][3/4 or 1 inch (19 or 25 mm)]** .
 - e. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>** .
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: **[Enhanced][or][smooth]** .

7. Tube Sheets:
 - a. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 - b. Intermediate Tube Sheets: Carbon-steel plates drilled and reamed to accommodate tubes; welded to shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
8. Water Boxes: Install removable water boxes arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - a. Attachment: Bolt and gasket water boxes to end tube sheets to provide a watertight seal.
 - b. Material: Carbon-steel construction.
 - c. Type: **[Standard][or][Marine]** type water boxes for water boxes with piping connections. Standard type water boxes for water boxes without piping connections.
 - d. Lifting Provisions: Provide water boxes **[and marine water-box covers]** with lifting lugs or eyebolts.
 - e. Hinged Water Boxes: Install hinges on one side of water box for ease of opening and to support the weight of water box when opened.
 - f. Hinged Marine Water-Box Covers: Install hinges on one side of cover for ease of opening and to support the weight of cover when opened.
 - g. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]** .
 - h. Fluid-Temperature Monitoring: Thermistor or RTD temperature sensor factory installed in each nozzle to monitor fluid temperature and report information to chiller control panel.
 - i. Drain Connections: Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension>** NPT connection and threaded plug at low point of water box.
 - j. Vent Connections: Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension>** NPT connection and threaded plug at high point of water box.
9. Additional Corrosion Protection:
 - a. Anodes: Factory install easily replaceable electrolytic corrosion-inhibitor **[zinc][or][magnesium]** anodes inside of water boxes.
 - b. Corrosion-Resistant Finish: Coat wetted surfaces with a corrosion-resistant finish.
- O. Chillers Without Integral Condensers: Provide chillers without an integral condenser and design chillers for field connection to remote condenser. Coordinate requirements with Section 236313 "Air-Cooled Refrigerant Condensers."
- P. Heat-Reclaim Condensers:
 1. Design: Shell-and-tube design with fluid in tubes and refrigerant surrounding tubes within shell. Heat-reclaim condenser shell is separate from evaporator.
 2. Code Compliance: Tested and stamped in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 3. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
 4. Hot-Gas Dispersion: Design and factory-install baffle plates or other means to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
 5. Tubes:

- a. Individually field-replaceable from either end and without damage to tube sheets and other tubes.
 - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - c. Material: **[Copper][Copper-nickel alloy][Copper or copper-nickel alloy]<Insert material>** .
 - d. Nominal OD: **[Manufacturer's choice][3/4 inch (19 mm)][1 inch (25 mm)][3/4 or 1 inch (19 or 25 mm)]** .
 - e. Minimum Wall Thickness: **[Manufacturer's choice][0.025 inch (0.6 mm)][0.028 inch (0.7 mm)][0.035 inch (0.9 mm)]<Insert dimension>** .
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: **[Enhanced][or][smooth]** .
6. Tube Sheets:
- a. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 - b. Intermediate Tube Sheets: Carbon-steel plates drilled and reamed to accommodate tubes; welded to shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
7. Water Boxes: Install removable water boxes arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
- a. Attachment: Bolt and gasket water boxes to end tube sheets to provide a watertight seal.
 - b. Material: Carbon-steel construction.
 - c. Type: **[Standard][or][Marine]** type water boxes for water boxes with piping connections. Standard type water boxes for water boxes without piping connections.
 - d. Lifting Provisions: Provide water boxes **[and marine water-box covers]** with lifting lugs or eyebolts.
 - e. Hinged Water Boxes: Install hinges on one side of water box for ease of opening and to support the weight of water box when opened.
 - f. Hinged Marine Water-Box Covers: Install hinges on one side of cover for ease of opening and to support the weight of cover when opened.
 - g. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange][Welded, ASME B16.5, raised-face flange][Grooved for mechanical-joint coupling][Grooved with mechanical-joint coupling and flange adapter]** .
 - h. Fluid-Temperature Monitoring: Thermistor or RTD temperature sensor factory installed in each nozzle to monitor fluid temperature and report information to chiller control panel.
 - i. Drain Connections: Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension>** NPT connection and threaded plug at low point of water box.
 - j. Vent Connections: Fit each water box with **[3/4-inch (19-mm)][1-inch (25-mm)][3/4- or 1-inch (19- or 25-mm)]<Insert dimension>** NPT connection and threaded plug at high point of water box.
8. Additional Corrosion Protection:
- a. Anodes: Factory install easily replaceable electrolytic corrosion-inhibitor **[zinc][or][magnesium]** anodes inside of water boxes.
 - b. Corrosion-Resistant Finish: Coat wetted surfaces with a corrosion-resistant finish.

Q. Electrical Power:

1. Factory installed and wired, and functionally tested at factory before shipment.

2. Single-Point Field-Power Connections: Provide chiller with single-point, field-power connection to **[wiring lugs][NEMA BS 31047, heavy-duty, fused disconnect switch][NEMA BS 31047, heavy-duty, nonfused disconnect switch][UL 489, instantaneous-trip circuit breaker]** .
 - a. Enclosure: NEMA 250, **[Type 1]<Insert type>** .
 - b. Withstand Rating: Minimum withstand rating is to be as required by electrical power distribution system, but not less than **[42,000][65,000][100,000]<Insert value>** A.
 - c. Electrical Power for Controls: Factory-install a control-circuit transformer with primary and secondary side fuses for chillers with single-point, field-power connection.
3. Field-Power Connections: Provide chiller with manufacturer's standard multiple field-power connections to **[wiring lugs][NEMA BS 31047, heavy-duty, fused disconnect switch][NEMA BS 31047, heavy-duty, nonfused disconnect switch][UL 489, instantaneous-trip circuit breaker]** .
 - a. Enclosure: NEMA 250, **[Type 1]<Insert type>** .
 - b. Withstand Rating: Minimum withstand rating is to be as required by electrical power distribution system, but not less than **[42,000][65,000][100,000]<Insert value>** A.
 - c. Electrical Power for Controls: Dedicated single-point, field-power connection to chiller controls.
 - d. Where indicated, configure chiller power to allow chiller operation with only one compressor and power to other chiller compressor(s) disconnected and isolated for service.
4. Branch Circuits: Provide branch power circuit to each motor, electric heater, dedicated electrical load, and controls **[with disconnect switch or circuit breaker]** with same withstand rating to match main disconnecting means.
 - a. Factory-install a NEMA ICS 2-rated motor controller, hand-off-auto switch, and overcurrent protection for each auxiliary motor.
5. Terminal Blocks: Terminal blocks with numbered **[and color-coded]** wiring to match wiring diagram. Include spare wiring terminal block for connection to external controls or equipment.
6. Electrical Power Wiring Raceways: Factory-install electrical power wiring outside of enclosures in metal raceways. Terminate connections to each motor and heater with not more than **[24-inch (610-mm)]<Insert dimension>** length of **[liquidtight][or][flexible]** conduit.
7. Power Factor Correction: Factory install and wire a capacitor bank for the purpose of power factor correction to **[0.95]<Insert value>** at all operating conditions.
 - a. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
 - b. Capacitors are to be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAR ratings are to be indicated and not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
 - c. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within one minute after de-energizing.
 - d. Provide a ground terminal and a terminal block or individual connectors for phase connection.
- R. Constant-Speed Motor Controllers: Factory-furnished and **[field]** installed for use with constant-speed motors.
 1. Enclosure: NEMA 250, **[Type 1]<Insert type>** , with hinged full-front access door **[with lock and key or padlock and key]** .

2. Control Circuit: Power obtained from [integral control power transformer]<Insert source of control power> with enough capacity to operate connected control devices.
3. Overload Relays: Size overload relays in accordance with UL 1995 or to be an integral component of chiller control microprocessor.
4. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
5. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed or open transition.
6. Accessories: Devices are to be factory installed in controller enclosure unless otherwise indicated.
 - a. Disconnect Type: Externally Operated [, door-interlocked] disconnect; [NEMA BS 31047, heavy-duty, fused disconnect switch][NEMA BS 31047, heavy-duty, nonfused disconnect switch][UL 489, instantaneous-trip Circuit breaker] . Minimum withstand rating is to be as required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
 - b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
 - c. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
 - d. Control Relays: Time-delay relays.
 - e. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
 - f. Number-of-Starts Counter: Numerical readout on face of enclosure.
 - g. Meters: Panel type, [2-1/2 inches (64 mm)][4-1/4 inches (108 mm)] with [90][120][270] - degree scale and [1][2] percent accuracy. Where indicated, provide transfer device with an off position. Meters are to indicate the following:
 - 1) Ammeter: Output current for each phase, with current sensors rated to suit application.
 - 2) Voltmeter: Output voltage for each phase.
 - 3) Frequency Meter: Output frequency.
 - 4) Real-time clock with current time and date.
 - 5) Total run time.
 - h. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
 - 1) Selectable, digital display of the following:
 - a) Phase Currents, Each Phase: Within [1]<Insert value> percent.
 - b) Phase-to-Phase Voltages, Three Phase: Within [1]<Insert value> percent.
 - c) Phase-to-Neutral Voltages, Three Phase: Within [1]<Insert value> percent.
 - d) Three-Phase Real Power: Within [2]<Insert value> percent.
 - e) Three-Phase Reactive Power: Within [2]<Insert value> percent.
 - f) Power Factor: Within [2]<Insert value> percent.
 - g) Frequency: Within [0.5]<Insert value> percent.
 - h) Integrated Demand with Demand Interval: Selectable from [5 to 60]<Insert range> Minutes: Within [2]<Insert value> percent.
 - i) Accumulated Energy, in Megawatt Hours (Joules): Within [2]<Insert value> percent; stored values unaffected by power outages for up to [72]<Insert value> hours.
 - 2) Mounting: Display and control unit flush or semirecessed in instrument compartment door.
 - i. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
 - j. Power Protection: Chiller is to shut down within [six]<Insert value> cycles of power

interruption.

- S. Variable-Frequency Controllers: Factory-furnished and installed for use with variable-speed motors.
1. Factory mount motor controllers and wire chiller to provide a [multipoint][single-point] , field-power termination to the chiller and its auxiliaries.
 - a. Where indicated, install a variable-frequency controller for each variable-speed motor to allow operation of one motor with the other motor(s) disconnected and isolated for service.
 2. Design: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
 3. Enclosure: Unit mounted, NEMA 250, [Type 1]<Insert type> , with hinged full-front access door with lock and key.
 4. Integral Disconnecting Means: [Door-interlocked,] UL 489, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating is to be as required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
 5. Technology: Pulse-width-modulated output suitable for constant or variable torque loads.
 6. Output Rating: Three-phase; with voltage proportional to frequency throughout voltage range.
 7. Operating Requirements:
 - a. Input AC Voltage Tolerance: [Chiller voltage indicated, plus 10 percent]<Insert voltage and tolerance> .
 - b. Input Frequency: Tolerance of 60 Hz, plus or minus [2]<Insert value> Hz.
 - c. Capable of driving full load, without derating, under the following conditions:
 - 1) Ambient Temperature: [0 to 40]<Insert temperature range> deg C.
 - 2) Relative Humidity: Up to [90][95] percent (noncondensing).
 - 3) Altitude: [3300 ft. (1005 m)][6600 ft. (2010 m)] .
 - d. Minimum Efficiency: [96]<Insert value> percent at 60 Hz, full load.
 - e. Minimum Displacement Primary-Side Power Factor: [98]<Insert value> percent.
 - f. Overload Capability: [1.05]<Insert value> times the full-load current for seven seconds.
 - g. Starting Torque: As required by compressor-drive assembly.
 - h. Speed Regulation: Within [1]<Insert value> percent.
 - i. Isolated Control Interface: To allow controller to follow control signal over a [5:1][10:1]<Insert value> speed range.
 - j. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller is not to operate continuously.
 - k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
 8. Internal Adjustability Capabilities:
 - a. Minimum Output Frequency: [6]<Insert value> Hz.
 - b. Maximum Output Frequency: [60]<Insert value> Hz.
 - c. Acceleration: [2]<Insert value> to [60]<Insert value> seconds.
 - d. Deceleration: Zero to [60]<Insert value> seconds.
 - e. Current Limit: [30]<Insert value> to 100 percent of maximum rating.
 9. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions is to not result in component failure or the need for replacement:
 - a. Overtemperature.
 - b. Short circuit at controller output.

- c. Ground fault at controller output. Variable-frequency controller is to be able to start a grounded motor.
 - d. Open circuit at controller output.
 - e. Input undervoltage.
 - f. Input overvoltage.
 - g. Loss of input-phase.
 - h. Reverse phase.
 - i. AC line switching transients.
 - j. Instantaneous overload, line to line or line to ground.
 - k. Sustained overload exceeding 100 percent of controller rated current.
 - l. Starting a rotating motor.
10. Motor Protection: Controller to protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
11. Automatic Reset and Restart: Capable of **[three]<Insert number>** restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller is to be capable of automatic restart on phase-loss, and overvoltage and undervoltage trips.
12. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:
 - a. Power on.
 - b. Run.
 - c. Overvoltage.
 - d. Line fault.
 - e. Overcurrent.
 - f. External fault.
 - g. Motor speed (percent).
 - h. Fault or alarm status (code).
 - i. Motor output voltage.
 - j. Input kilovolt amperes.
 - k. Total power factor.
 - l. Input kilowatts.
 - m. Input kilowatt-hours.
 - n. Three-phase input voltage.
 - o. Three-phase output voltage.
 - p. Three-phase input current.
 - q. Three-phase output current.
 - r. Three-phase input voltage THD.
 - s. Three-phase input current THD.
 - t. Output frequency (Hertz).
 - u. Elapsed operating time (hours).
 - v. Diagnostic and service parameters.
13. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.
14. Control Signal Interface:
 - a. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and **[six]<Insert value>** programmable digital inputs.
 - b. Manufacturer has option to incorporate control signal interface into chiller control panel.
15. Active Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to **[5]<Insert number>** percent.
 - a. Limit variable-frequency controller voltage Total Harmonic Distortion (THD) and current

Total Demand Distortion (TDD) to comply with IEEE 519 requirements.

T. Controls:

1. Standalone and microprocessor based with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
2. Enclosure: Unit mounted, NEMA 250, [Type 1][Type 3R]<Insert type> , hinged or lockable.
3. Control Wiring Raceways: Factory-install control wiring outside of enclosures in metal raceway. Terminate connections to each control device with not more than a [24-inch (610-mm)]<Insert dimension> length of [liquidtight][or][flexible] conduit.
4. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
 - a. Date and time.
 - b. Operating or alarm status.
 - c. Fault history with not less than last [10][5]<Insert value> faults displayed.
 - d. Set points of controllable parameters.
 - e. Trend data.
 - f. Operating hours.
 - g. Number of chiller starts.
 - h. Outdoor-air temperature or space temperature if required for chilled-water reset.
 - i. Temperature and pressure of operating set points.
 - j. Entering- and leaving-fluid temperatures of evaporator and condenser.
 - k. Difference in fluid temperatures of evaporator and condenser.
 - l. Refrigerant pressures in evaporator and condenser.
 - m. Refrigerant saturation temperature in evaporator and condenser.
 - n. Elapsed time meter (compressor run status).
 - o. Pump status.
 - p. Antirecycling timer status.
 - q. Percent of maximum motor amperage.
 - r. Current-limit set point.
 - s. Number of compressor starts.
 - t. Compressor bearing temperature.
 - u. Motor bearing temperature.
 - v. Motor winding temperature.
 - w. Oil temperature.
 - x. Oil discharge pressure.
 - y. Phase current.
 - z. Percent of motor rated load amperes.
 - aa. Phase voltage.
 - bb. Demand power (kilowatts).
 - cc. Energy use (kilowatt-hours).
 - dd. Power factor.
5. Control Functions:
 - a. Manual or automatic startup and shutdown time schedule.
 - b. Entering and leaving chilled-water temperatures, control set points, and motor load limits.
 - c. Evaporator Leaving Fluid Temperature Reset: Reset leaving evaporator-fluid temperature based on [return-fluid temperature][outdoor-air temperature][space temperature][remote terminal unit control valve position]<Insert reset variable> temperature.
 - d. Current limit and demand limit.
 - e. Condenser-fluid temperature.

- f. External chiller emergency stop.
 - g. Antirecycling timer.
 - h. Automatic lead-lag switching.
 - i. Variable evaporator flow.
 - j. Thermal storage.
 - k. Dual mode operation with thermal storage.
 - l. Heat pump.
 - m. Heat reclaim.
6. Manually Reset Safety Controls: The following conditions are to shut down chiller and require manual reset:
 - a. Low evaporator refrigerant pressure or temperature.
 - b. High condenser refrigerant pressure.
 - c. Low evaporator fluid temperature.
 - d. Low oil differential pressure.
 - e. High or low oil pressure.
 - f. High oil temperature.
 - g. High compressor-discharge temperature.
 - h. Loss of condenser-fluid flow.
 - i. Loss of evaporator-fluid flow.
 - j. Motor overcurrent.
 - k. Motor overvoltage.
 - l. Motor undervoltage.
 - m. Motor phase reversal.
 - n. Motor phase failure.
 - o. Sensor- or detection-circuit fault.
 - p. Processor communication loss.
 - q. Motor controller fault.
 - r. Extended compressor surge.
7. Trending: Capability to trend analog data of up to **[three][five]<Insert value>** parameters simultaneously over an adjustable period and frequency of polling.
8. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
9. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
10. Communication Port: USB 2.0 port or higher, capable of connecting to a notebook computer **[tablet][smart phone][or][printer]** .
11. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.
 - a. Hardwired Points:
 - 1) Monitoring: On-off status, **[common trouble alarm][electrical power demand (kilowatts)][electrical power consumption (kilowatt-hours)][power factor]<Insert monitoring point>** .
 - 2) Control: On-off operation, **[leaving evaporator-fluid temperature set-point adjustment][electrical power demand limit]<Insert control point>** .
 - b. Serial Communication Interface: **[ASHRAE 135 (BACnet) IP][ASHRAE 135 (BACnet) MS/TP][LonTalk][Modbus TCP/IP][Modbus RTU][Industry-accepted, open-protocol]<Insert type of interface>** communication interface with the DDC system for HVAC is to enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed

locally at chiller control panel are to be available through the DDC system for HVAC.

U. Insulation:

1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C534/C534M, Type I for tubular materials and Type II for sheet materials.
2. Minimum Thickness: **[3/4 inch (19 mm)][1-1/2 inches (38 mm)]<Insert dimension>** .
3. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
4. General Requirements for Factory-Applied Insulation:
 - a. Before insulating steel surfaces, prepare surfaces for paint.
 - b. Prime and paint steel surfaces to be insulated as indicated for other painted components.
 - c. Do not insulate unpainted steel surfaces.
 - d. Seal seams and joints to provide a vapor barrier.
 - e. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
 - f. Manufacturer has option to factory or field insulate chiller components installed in multiple pieces to reduce potential for damage during installation.
 - g. Manufacturer has option to factory or field insulate water boxes and nozzles to reduce potential for damage during installation.
5. Field-Applied Insulation:
 - a. Chiller components that require factory-applied insulation and are not factory insulated are to be field insulated to comply with requirements indicated.
 - b. Chiller manufacturer is responsible for all chiller factory-applied insulation whether factory or field installed, to ensure chiller manufacturer is the single point of responsibility for chillers.
 - c. Chiller manufacturer factory-authorized service representative to instruct, supervise, and approve installation of field-applied insulation and paint.
 - d. After field-applied insulation is complete, paint insulation to match factory-applied finish.
6. Insulation on Cold Surfaces: Factory-apply insulation over cold surfaces of chiller capable of forming condensation. Components are to include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, compressor motor, and auxiliary piping.
7. Insulation on Hot Surfaces: For applications that use chillers to supply heating, factory-apply insulation over hot surfaces of chiller for thermal performance and personnel safety. Components are to include, but not be limited to, **[evaporator,]** condenser **[, heat-reclaim condenser]** shell and end tube sheets, water boxes including nozzles, **[refrigerant suction pipe from evaporator to compressor,]** refrigerant discharge pipe from compressor to condenser, hot surfaces of compressor, compressor motor and auxiliary piping.

V. Finish:

1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
 - a. Primer: Provide at least one coat of primer with a total dry film thickness of at least **[2 mils (0.05 mm)]<Insert thickness>** .
 - b. Paint Type: Provide at least two finish coats of **[alkyd-modified, vinyl enamel][epoxy][polyurethane][manufacturer's standard coating]** .
 - c. Paint Thickness: Total dry film thickness of at least **[4 mils (0.10 mm)]<Insert thickness>**

- d. Insulated Surfaces:
 - 1) Paint surfaces that are to be insulated before applying the insulation.
 - 2) Paint installed insulation to match adjacent uninsulated surfaces.
 - e. Finish Coat Color: Color of finish coat to be **[manufacturer's standard][custom color selected by Architect]<Insert color description>** .
2. Provide Owner with the following:
- a. Closeout Submittal Data: Submit paint manufacturer and paint product details for Owner to procure matching paint in the future.
 - b. Spare Paint: Turn over to Owner a **[one-quart]<Insert size>** container of paint that was used in application of finish coat to use in touchup applications at Project closeout. Properly label container for ease of future reference.

W. Accessories:

- 1. Flow Switches: If required for chiller operation and not factory installed, chiller manufacturer to furnish flow switches for field-mounting with installation instructions.
 - a. Paddle Flow Switches:
 - 1) Type: Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
 - 2) Pressure Rating: Pressure rating equal to not less than pressure rating of heat exchanger.
 - 3) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of **[10 A at 120 V ac]<Insert rating>** .
 - 4) Enclosure: House switch in a NEMA 250, **[Type 4]<Insert type>** enclosure constructed of die-cast aluminum.
 - 5) Construction: Construct body and wetted parts of Type 316 stainless steel.
 - 6) Vane: Vane length to suit installation.
 - b. Pressure Differential Switches:
 - 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
 - 2) Performance: Switch is to withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
 - 3) Set Point: Screw type, field adjustable.
 - 4) Electrical Connections: Internally mounted screw-type terminal blocks.
 - 5) Switch Enclosure: NEMA 250, **[Type 4]<Insert type>** .
 - 6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
 - c. Thermal Dispersion Type Flow Sensors/Switches: Chiller manufacturer standard offering.
 - 1) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
 - 2) Factory calibrated for Project-specific application.
- 2. Vibration Isolation: Chiller manufacturer to furnish chillers with vibration isolation and installation instructions for field-mounting.

- a. Neoprene Pads:
 - 1) Two layers of **0.375-inch- (10-mm-)** thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gauge, stainless steel plate.
 - 2) Fabricate pads from 40- to 50-durometer neoprene.
 - 3) Provide stainless steel square bearing plate to load the pad uniformly between **20 and 40 psig (138 and 276 kPa)** with a **0.12- to 0.16-inch (3- to 4-mm)** deflection.
- 3. Sound-Barrier Covers:
 - a. Furnish removable and reusable sound-barrier covers over the compressor housing, motor, compressor suction and discharge piping, and other components as required to achieve sound performance indicated.
 - b. Design sound-barrier covers for repeated installation and removal without use of tape, caulk, and special tools.
 - c. Inner and outer surfaces of cover to consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
 - d. Double sew and lock stitch covers with edges folded and sewn so no raw cut edges are exposed.
 - e. Form covers around control devices, gauges, conduit, piping, and supports without degrading sound-barrier performance.
 - f. Continuously lap all exposed joints and seams at least **2 inches (50 mm)** for better sound containment.
 - g. Permanently label each section of sound-barrier cover to indicate its location, description, size, and number sequence. Affix a sound-barrier installation diagram on chiller in an easily visible location.
 - h. Randomly place stainless steel quilting pins to prevent covers from shifting and sagging.
- 4. Sound-Reduction Enclosures: Chiller manufacturer standard factory-furnished [, **field-installed**] acoustic enclosure(s) around the compressors, drive assemblies, and other noise-generating components that are designed to reduce chiller sound levels without affecting performance.

2.4 MODULAR, HOUSED, WATER-COOLED ROTARY-SCREW WATER CHILLER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - 1. **[WaterFurnace International, Inc.]**
 - 2. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[WaterFurnace International, Inc.]**
 - 2. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain modular, housed, water-cooled rotary-screw water chillers from single manufacturer.
- D. Description: Modular, housed, water-cooled rotary-screw water chiller/heater producing chilled water and simultaneously producing hot water.

- E. Housing/Modular Enclosure:
 - 1. Designed to fit through a [36 inch (0.9 m)]<Insert dimension> doorway.
 - 2. Each module individually isolatable for service without affecting operation of the rest of the modules in the bank/group.
 - 3. Can be banked/grouped in a row together and controlled as a bank/group of up to and including [10]<Insert number> modules of [140 ton (490 kW)]<Insert capacity> maximum capacity each.
- F. Compressor: Variable speed control.
- G. Compressor Motor: Permanent magnet motor with integrated drive.
- H. Capacity: Capable of producing [40 deg F (4.4 deg C)]<Insert temperature> chilled water and simultaneously producing [145 deg F (62.8 deg C)]<Insert temperature> hot water.
- I. Capacity Control:
 - 1. DC inverter variable speed control.
 - 2. Capable of capacity turndown to 25 percent of rated capacity.
 - 3. Electronic Expansion Valve: To provide superheat control as well as a wider range of operation; superheat values are to be reported back to system controller to allow diagnostic information to be available to the maintenance service technician without requiring use of refrigerant manifold gauges.
- J. Refrigerant: [R-513A, ASHRAE 34 Group A1]<Insert refrigerant> .
- K. Evaporator: Brazed plate.
- L. Condenser: Stainless steel.
- M. Electrical Power:
 - 1. Electrical Connection: Single point.
 - 2. Disconnect Switch: Factory mounted, internally wired, through the door.
 - 3. Withstand Rating: Minimum withstand rating is to be as required by electrical power distribution system, but not less than [65,000]<Insert value> A.
 - 4. Control-Circuit Transformer: Factory-installed control-circuit transformer with primary-side and secondary-side fuses.
- N. Controls:
 - 1. Control Hardware:
 - a. User Interface: Supervisory controller mounted in NEMA 250 hinged and keyed control box, including 15-amp electrical convenience outlet, color touch screen tablet with customizable 3-D graphical control interface for multiple chillers/pumps.
 - b. WiFi router.
 - c. Setpoint, aquastat or network control methods with adjustable PID parameters.
 - d. Eight, normally open, field-defined user relay outputs.
 - e. Two, 0-10V, field-defined analog outputs.
 - f. Six, 0-24VAC, field-defined digital inputs.
 - g. Two, 0-5V, field-defined pressure sensors.
 - h. Two, 0-100A, field-defined current transducer inputs.
 - i. Hardwired Points:
 - 1) Monitoring: On-off status, [common trouble alarm][electrical power demand

(kilowatts)][electrical power consumption (kilowatt-hours)][power factor]<Insert additional monitoring points as desired> .

- 2) Control: On-off operation, [leaving evaporator-fluid temperature set-point adjustment][electrical power demand limit]<Insert additional control points as desired> .

- j. Communication Interface: Supervisory controller is to provide for single point BAS integration via **[BACnet Advanced Workstation (B-AWS) and BACnet Building Controller (B-BC) compliant]**<Insert type of interface> . Communication interface with the DDC system for HVAC is to enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel are to be available through the DDC system for HVAC.

2. Control Functions:

- a. Compressor lead/lag control.
- b. Anti-short-cycle compressor protection.
- c. Minimum run time compressor protection.
- d. High refrigerant pressure and low refrigerant pressure cutouts.
- e. Loss of refrigerant charge protection.
- f. Slow-opening water valve timing.
- g. Selectable water coil freeze detection via refrigerant temperature and suction saturation temperature sensing.
- h. Selectable water coil freeze detection via internal heat exchanger fluid temperature sensing.
- i. Selectable water coil freeze alarm.
- j. Over/under voltage protection.
- k. Remote DIP switch override.
- l. Load shed.
- m. Emergency shutdown.
- n. Diagnostic LEDs.
- o. Test mode push-button switch.
- p. Fault retry with fault history.
- q. Source and load entering- and leaving-fluid temperatures.
- r. Alarm output with optional E-code pulsing.
- s. Four accessory output relays with normally open and normally closed contacts.
- t. Modbus communication protocol between sensors and control panel.
- u. Energy Monitoring: Monitoring of energy consumption data.
- v. Performance Monitoring: Monitoring of water flow and change in temperature.
- w. Refrigerant Monitoring: For performance feedback and for maintenance diagnostics.

O. Capacities and Characteristics:

1. Capacity: <Insert tons (kW)> .
2. Full-Load Efficiency:
 - a. COP: <Insert value> .
 - b. EER: <Insert value> .
 - c. Power Input/Cooling Output: <Insert kW/ton (kW/kW)> .
 - d. Comply with FEMP.
3. Part-Load Efficiency:
 - a. IPLV: <Insert value> .

- b. NPLV: <Insert value> .
 - c. Comply with FEMP.
4. Evaporator:
- a. Pressure Rating: <Insert psig (kPa)> .
 - b. Number of Passes: [One][Two][Three][Four] .
 - c. Fluid Type: [Water]<Insert fluid type> .
 - d. Design Fluid Flow Rate: <Insert gpm (L/s)> .
 - e. Minimum Fluid Flow Rate: <Insert gpm (L/s)> .
 - f. Entering-Fluid Temperature: <Insert deg F (deg C)> .
 - g. Leaving-Fluid Temperature: <Insert deg F (deg C)> .
 - h. Fluid Pressure Drop: <Insert feet of head (kPa)> .
 - i. Fluid Velocity: <Insert fps (m/s)> .
 - j. Fouling Factor: [0.0001 sq. ft. x h x deg F/Btu
(0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu
(0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu
(0.00011 sq. m x deg C/W)]<Insert value> .
5. Condenser:
- a. Pressure Rating: <Insert psig (kPa)> .
 - b. Number of Passes: [One][Two][Three] .
 - c. Fluid Type: [Water]<Insert fluid type> .
 - d. Design Fluid Flow Rate: <Insert gpm (L/s)> .
 - e. Minimum Fluid Flow Rate: <Insert gpm (L/s)> .
 - f. Entering-Fluid Temperature: <Insert deg F (deg C)> .
 - g. Leaving-Fluid Temperature: <Insert deg F (deg C)> .
 - h. Fluid Pressure Drop: <Insert feet of head (kPa)> .
 - i. Fluid Velocity: <Insert fps (m/s)> .
 - j. Fouling Factor: [0.0001 sq. ft. x h x deg F/Btu
(0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu
(0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu
(0.00011 sq. m x deg C/W)]<Insert value> .
6. Heat Reclaim Condenser:
- a. Pressure Rating: <Insert psig (kPa)> .
 - b. Number of Passes: [One][Two][Three] .
 - c. Fluid Type: [Water]<Insert fluid type> .
 - d. Design Fluid Flow Rate: <Insert gpm (L/s)> .
 - e. Minimum Fluid Flow Rate: <Insert gpm (L/s)> .
 - f. Entering-Fluid Temperature: <Insert deg F (deg C)> .
 - g. Leaving-Fluid Temperature: <Insert deg F (deg C)> .
 - h. Fluid Pressure Drop: <Insert feet of head (kPa)> .
 - i. Fluid Velocity: <Insert fps (m/s)> .
 - j. Fouling Factor: [0.0001 sq. ft. x h x deg F/Btu
(0.000018 sq. m x deg C/W)][0.00025 sq. ft. x h x deg F/Btu
(0.000044 sq. m x deg C/W)][0.0005 sq. ft. x h x deg F/Btu
(0.00011 sq. m x deg C/W)]<Insert value> .
7. Number of Refrigerant Circuits: [One][Two][One per compressor]<Insert number> .
8. Compressors:
- a. Number of Compressors: [Two]<Insert number> .
 - b. Rated Load Amperes/Compressor: <Insert value> .

- c. Locked-Rotor Amperes/Compressor: **<Insert value>** .
- 9. Packaged Chiller Electrical Requirements:
 - a. Power Connections: **[Single-point field power][Multi-point field power][Multi-point field power configured for operation of one chiller compressor with other chiller compressors deenergized and isolated for service]** .
 - b. Power Input: **<Insert kilowatts>** .
 - c. Power Factor: **[0.95]<Insert value>** .
 - d. Minimum Circuit Ampacity: **<Insert value>** .
 - e. Maximum Overcurrent Protection Device: **<Insert amperage>** .
 - f. Volts: **[208][240][480][600]<Insert value>** V ac.
 - g. Phase: Three.
 - h. Hertz: 60.
- 10. Chiller Control Electrical Requirements:
 - a. Power Connections: **[Fed through integral transformer][Separate field-power connection]** .
 - b. Power Input: **<Insert number>** kW.
 - c. Minimum Circuit Ampacity: **<Insert number>** A.
 - d. Maximum Overcurrent Protection Device: **<Insert number>** A.
 - e. Volts: **[120]<Insert number>** V ac.
 - f. Phase: Single.
 - g. Hertz: 60.
- 11. Noise Rating: **[85]<Insert dBA>** sound power level when measured in accordance with AHRI 575. Provide factory-installed sound treatment if necessary to achieve the performance indicated.
- 12. Rapid Restart and Loading Feature: Chiller to start and reach **[100]<Insert value>** percent of design capacity within **[160 seconds]<Insert seconds>** of a start signal or restart signal after electrical power interruption.

2.5 SOURCE QUALITY CONTROL

- A. Perform functional tests of chillers before shipping.
- B. ASME Testing: Factory test and inspect evaporator [**and condenser**][, **condenser, and heat-reclaim condenser**] in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- C. Eddy Current Testing:
 - 1. Perform factory testing of evaporator [**and condenser**][, **condenser, and heat-reclaim condenser**] tubes of each chiller to ensure tube quality and longevity.
 - 2. Submit test report, including, at a minimum:
 - a. List of equipment used and equipment settings.
 - b. Test data reports and accompanying strip charts of calibrations.
 - c. Identify tubes with significant defects and typical indications.
 - d. Statistical summary of defect indications.
 - e. Recommendations concerning tube condition, tube replacement, tube removal for evaluation, and future frequency of testing.
 - f. Approval by an American Society for Nondestructive Testing, Level III eddy current technician.

- D. Factory Performance Testing: Factory performance test water-cooled chillers, before shipping, in accordance with **AHRI 550/590 (AHRI 551/591)**:
1. Test the following conditions:
 - a. Design conditions indicated.
 - b. Part-Load Testing:
 - 1) Reduction in capacity from design to minimum load in steps of [10][25][33]<Insert number> with condenser fluid at design conditions and with leaving evaporator-fluid temperature at design conditions.
 - 2) Reduction in capacity from design to minimum load in steps of [10][25][33]<Insert number> with varying entering condenser-fluid temperature from design to minimum conditions in [5 deg F (3 deg C)]<Insert temperature> increments and with leaving evaporator-fluid temperature constant at design conditions.
 - 3) Reduction in capacity from design to minimum load in steps of [10][25][33]<Insert number> with varying entering condenser-fluid temperature from design to minimum conditions in [5 deg F (3 deg C)]<Insert temperature> increments and with varying leaving evaporator-fluid temperature from design conditions to maximum conditions in [2 deg F (1 deg C)]<Insert temperature> increments.
 - 4) At [one][two][three][four][five][10]<Insert number> point(s) of varying part-load performance to be selected by Owner at time of test.
 2. Witness Testing: Allow [Owner]<Insert entity> access to place where chillers are being tested to witness testing. Notify [Owner][Architect]<Insert entity>[14]<Insert number> days in advance of testing.
 3. Test Reports: Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit a PDF copy of test report within [5]<Insert number> business days of test date.
- E. Factory Sound Testing: Factory sound test water-cooled chillers, before shipping, in accordance with AHRI 575:
1. Test the following conditions:
 - a. Design conditions indicated.
 - b. Chiller operating at calculated worst-case sound condition.
 - c. Additional Conditions Tested: At [one][two][three][four][five]<Insert number> point(s) of varying part-load performance to be selected by Owner at time of test.
 2. Witness Testing: Allow [Owner]<Insert entity> access to place where chillers are being tested to witness testing. Notify [Owner][Architect]<Insert entity>[14]<Insert number> days in advance of testing.
 3. Test Reports: Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit a PDF copy of test report within [5]<Insert number> business days of test date.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine chillers before installation. Reject chillers that are damaged.
- B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls connections, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.



1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF WATER-COOLED, ROTARY-SCREW WATER CHILLERS

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

C. Install chillers on support structure indicated on Drawings.

D. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Maintain manufacturer's recommended clearances for proper operation, service, and maintenance.

F. Charge chiller with refrigerant and fill with oil if not factory installed.

G. Install separate devices furnished by manufacturer and not factory installed.

H. Repair damage to chiller factory-installed insulation. Replace insulation if damage is extensive.

I. Repair damage to chiller painted surfaces.

3.3 PIPING CONNECTIONS

A. Hydronic Piping Requirements: Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

B. Refrigerant Piping Requirements: Comply with requirements for piping specified in Section 232300 "Refrigerant Piping."

C. Drawings indicate general arrangement of piping, fittings, and specialties.

D. Install piping adjacent to chiller to allow service and maintenance.

E. Evaporator Fluid Connections:

1. Inlet Connections: Connect to evaporator inlet with piping that includes shutoff valve, **[strainer],[flexible connector]**, thermometer with thermowell, and plugged branch tee with shutoff valve and pressure gauge and drain connection with valve.
2. Outlet Connections: Connect to evaporator outlet with piping that includes shutoff valve,

- balancing valve, [**flexible connector**,] flow switch, thermometer with thermowell, plugged branch tee with shutoff valve and pressure gauge, [**flow meter**,] and drain connection with valve.
3. Final Connections: Make mating connections to chiller with a [**flange**][or][**mechanical coupling**] .
- F. Condenser Fluid Connections:
1. Inlet Connections: Connect to condenser inlet with piping that includes shutoff valve, [**strainer**,][**flexible connector**,] thermometer with thermowell, and plugged branch tee with shutoff valve and pressure gauge and drain connection with valve.
 2. Outlet Connections: Connect to condenser outlet with piping that includes shutoff valve, balancing valve, [**flexible connector**,] flow switch, thermometer with thermowell, plugged branch tee with shutoff valve and pressure gauge, [**flow meter**,] and drain connection with valve.
 3. Final Connections: Make mating connections to chiller with a [**flange**][or][**mechanical coupling**] .
- G. Heat-Reclaim Condenser Fluid Connections:
1. Inlet Connections: Connect to condenser inlet with piping that includes shutoff valve, [**strainer**,][**flexible connector**,] thermometer with thermowell, and plugged branch tee with shutoff valve and pressure gauge and drain connection with valve.
 2. Outlet Connections: Connect to condenser outlet with piping that includes shutoff valve, balancing valve, [**flexible connector**,] flow switch, thermometer with thermowell, plugged branch tee with shutoff valve and pressure gauge, [**flow meter**,] and drain connection with valve.
 3. Final Connections: Make mating connections to chiller with a [**flange**][or][**mechanical coupling**] .
- H. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend [**vent piping**][**separate vent piping for each chiller**] to the outdoors without valves or restrictions.
1. Comply with ASHRAE 15 and governing code.
 2. Connect vent pipe to chiller pressure relief device with flexible connector and dirt leg with drain valve at low point.
 3. Terminate each vent pipe with a vent cap.
- I. Water Box Drain Connections: Connect each chiller water box drain connection with a [**full size drain valve**,][**union and drain pipe, and extend pipe, full-size of connection, to floor drain. Provide a shutoff valve at each connection.**]
- J. Water Box Vent Connections: Connect each chiller heat exchanger vent connection with a full-size [**manual air vent**][or][**automatic air vent**] . Provide a full-size shutoff valve at each connection.
- 3.4 ELECTRICAL CONNECTIONS
- A. Furnish and install electrical power to products requiring electrical power connections.
 - B. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260523 "Control-Voltage Electrical Power Cables."
 - C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
 - D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."
 - E. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
 - F. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit

number feeding connection.

1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.
- B. Install control signal wiring to field-mounted control devices and between chiller control interface and **[DDC control system]<Insert system description>** for remote monitoring and control of chillers. Comply with requirements in **[Section 230923 "Direct Digital Control (DDC) System for HVAC."]<Insert Section number and title.>**
- C. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."
- E. Install control devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- F. Install nameplate for each control connection, indicating brief description, controller designation and controller I/O point number feeding connection.
 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 SYSTEM STARTUP

- A. Engage a factory-authorized service representative to perform startup service.
 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
 3. Verify that pumps are installed and functional.
 4. Verify that thermometers and pressure gauges are installed.
 5. Operate chiller for run-in period.
 6. Check bearing lubrication and oil levels.
 7. Verify that refrigerant pressure relief device is vented outdoors.
 8. Verify proper motor rotation.
 9. Verify static deflection of vibration isolators during chiller startup, normal operation, and shutdown.
 10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator [**and condenser**][, **condenser, and heat-reclaim condenser**] .
 11. Verify and record performance of chiller protection devices.
 12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
- C. Prepare test and inspection startup reports.

3.7 WARRANTY PERIOD TESTING

- A. Within **[one]<Insert number>** month(s) of warranty period expiration, perform testing, analysis, and reporting indicated for each chiller.
- B. Eddy Current Testing:
 - 1. Solicit services of a third-party testing agency, specializing in such analysis, to perform testing of evaporator and condenser tubes, to ensure tube quality and longevity.
 - 2. Submit test report to Owner, including, at a minimum:
 - a. List of equipment used and equipment settings.
 - b. Test data reports and accompanying strip charts of calibrations.
 - c. Identification of tubes with significant defects and typical indications.
 - d. Statistical summary of defect indications.
 - e. Recommendations concerning tube condition, tube replacement, tube removal for evaluation, and future frequency of testing.
 - f. Approval by an American Society for Nondestructive Testing, Level III eddy current technician.
- C. Oil Analysis:
 - 1. Take oil sample and solicit services of a third-party testing agency, specializing in such analysis, to perform oil analysis.
 - 2. Submit analysis results and recommendations to Owner.
- D. Refrigerant Analysis:
 - 1. Take refrigerant sample and solicit services of a third-party testing agency, specializing in such analysis, to perform refrigerant analysis.
 - 2. Submit analysis results and recommendations to Owner.
- E. Site Access and Scheduling:
 - 1. Contact Owner to schedule testing at least 30 days in advance of testing.
 - 2. Make mutually agreeable schedule adjustments to accommodate Owner's request for testing.
 - 3. Review, with Owner, requirements for visitors in advance of testing.
 - 4. Comply with Owner requirements for visitors while on-site.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers. [**Video record the training sessions and provide electronic copy to Owner.**]
 - 1. Instructor must be factory trained and certified.
 - 2. Minimum Training:

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



- a. Provide not less than [eight]<Insert number> hours of training.
 - b. Provide not less than [16]<Insert number> hours of training spread across consecutive days, not to exceed [eight]<Insert number> hours per day.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
 4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 5. Obtain Owner sign-off that training is complete.
 6. Owner training is to be held at Project site.

END OF SECTION 23 64 26 16

SECTION 23 65 13 16 - CLOSED-CIRCUIT, FORCED-DRAFT COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes factory-assembled, closed-circuit, forced-draft cooling towers.

1.2 DEFINITIONS

- A. SCCR: Short-circuit current rating.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, pressure drop, fan performance data, rating at selected points indicated, and furnished specialties and accessories.
 - 2. Maximum flow rate.
 - 3. Minimum flow rate.
 - 4. Pressure required at cooling tower supply piping connections.
 - 5. Pressure required at basin heater supply piping connections.
 - 6. Pressure required at collection basin sweeper supply piping connections.
 - 7. Drift loss as percent of design flow rate.
 - 8. Volume of water in suspension for purposes of sizing remote storage.
 - 9. Sound:
 - a. Sound pressure levels for operation with fan off, fan at minimum speed, and design speed. If sound requirements are indicated at a specific distance, submit performance using same distance for comparative analysis.
 - b. Sound power levels in eight octave bands for operation with fans off, fans at minimum speed, and design speed.
 - 10. Performance curves for the following:
 - a. Varying entering-water temperatures from design to minimum in [one][five]<Insert number>-degree temperature increments.
 - b. Varying ambient wet-bulb temperatures from design to minimum in [one][five]<Insert number>-degree temperature increments.
 - c. Varying water flow rates from design to minimum in increments of [10]<Insert number> percent of flow rate difference between design and minimum flow rates.
 - d. Varying fan operation from design to minimum speed in [5][10]<Insert number> percent speed increments, and with fan off.
 - 11. Fan airflow at design conditions, brake horsepower, and drive losses (indicated in horsepower and percentage of brake horsepower).
 - 12. Fan motor electrical characteristics, including but not limited to, speed, voltage, phase hertz, amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
 - 13. Pump flow rate, head, brake horsepower, and efficiency.
 - 14. Pump motor electrical characteristics, including but not limited to, speed, voltage, phase hertz,

- amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
15. Electrical power requirements for each cooling tower component requiring power.

B. Shop Drawings:

1. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
2. Assembled unit dimensions.
3. Diagram showing each separate piece requiring field assembly.
4. Shipped sub-assembly dimensions and weights for field assembly.
5. Assembled unit weight without water.
6. Operating weight and load distribution.
7. Unit vibration isolation[**and seismic controls**].
8. Required clearances for maintenance and operation.
9. Sizes and dimensioned locations of piping and wiring connections.
10. Diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment.
3. Design Calculations: Calculate requirements for selecting vibration isolators[**and seismic restraints**][**and wind restraints**] and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Drawings on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - a. Structural supports.
 - b. Piping roughing-in requirements.
 - c. Conduit and wiring roughing-in requirements for controls and electrical power, including spaces reserved for controls and electrical equipment.
 - d. Access requirements, including working clearances for controls and electrical equipment, and service clearances. Mark and label clearances.
2. Drawings showing plans, sections, and elevation views, drawn to scale of at least **<Insert scale>**.
3. Each view to show screened background with the following:
 - a. Structural grids.
 - b. Adjacent walls, floors, and roofs.
 - c. Equipment and products of other trades that are located in vicinity of cooling towers and are part of final installation, such as controls, power, lighting, fire suppression systems, and plumbing systems.

B. Product Certificates: For certification required in "Quality Assurance" Article.

C. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control reports.

E. Field quality-control reports.

F. Field Test Reports: Include startup service reports.

G. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.
- B. Instructional Videos: Including those that are pre-recorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Belts:

1. Furnish **[one]<Insert number>** set(s) of matching belts for each unique belt configuration and size furnished.

B. Tool Kit:

1. A tool kit specially designed by cooling tower manufacturer for use in servicing cooling tower(s) furnished.
2. Special tools required to service components not readily available to Owner service personnel in performing routine maintenance.
3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Cooling Tower Tool Kit." Text size shall be at least **1 inch (25 mm)** high.
4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least **1/2 inch (13 mm)** high.

C. Touch-up Coating: **[32-oz. (1-L)]<Insert volume>** container of paint coating used. Label outside of container with detailed description of coating to allow for procurement of a matching coating in the future.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: **[Certified by CTI][An NRTL]**.

B. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

- C. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.
- D. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Coordinate requirements for multi-piece assembly for shipment. Limit the number of separate pieces for field installation to as few as possible.
- B. If factory assembly of multiple pieces is required for testing or other reasons, disassemble cooling tower into major assemblies as required by installation before packaging for shipment.
 - 1. Clearly label each package with a unique designation and include assembly instructions for each complete cooling tower.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:
 - 1. All components of cooling tower.
 - 2. Fan assembly, including fan, drive, and motor.
 - 3. **<Insert components requiring extended warranty>.**
 - 4. Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CLOSED-CIRCUIT, FORCED-DRAFT COOLING TOWERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Baltimore Aircoil Company]**
 - 2. **[EVAPCO, Inc]**
 - 3. **[Marley; a brand of SPX Cooling Technologies, Inc.]**
 - 4. **[Recold]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Baltimore Aircoil Company]**
 - 2. **[EVAPCO, Inc]**
 - 3. **[Marley; a brand of SPX Cooling Technologies, Inc.]**
 - 4. **[Recold]**
 - 5. **<Insert manufacturer's name>**

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cooling tower support structure[**and seismic restraints**][**and wind restraints**], including comprehensive engineering analysis.
- B. Structural Performance: Cooling tower and support structure shall withstand the effects of loads and stresses within limits and under conditions indicated according to [ASCE/SEI 7][IBC][governing code]<Insert requirement>.
- C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7]<Insert requirement>.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: [1.5][1.0].
 - 3. Component Amplification Factor: <Insert value>.
 - 4. Component Response Modification Factor: <Insert value>.
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- F. Operation Following Loss of Normal Power:
 - 1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to back-up power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought online.
 - 2. Include means and methods required to satisfy requirement even if not explicitly indicated.
- G. Vibration:
 - 1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry-standard requirements for cooling towers.
 - 2. Critical speed shall be at least 115 percent of design speed.

2.3 DESIGN ARRANGEMENT

- A. Counterflow pattern with inlet airflow from one side and forced-draft, bottom-mounted, axial fans; and with pressurized pipe distribution near top.
- B. Counterflow pattern with inlet airflow from one side and forced-draft, bottom-mounted, centrifugal fans; and with pressurized pipe distribution near top.
- C. Low-profile design with counterflow pattern, with inlet airflow from one side and forced-draft, side-mounted, centrifugal fans to reduce overall height; and with pressurized pipe distribution near top.

2.4 CASING AND FRAME

- A. Casing Material: **[Galvanized steel, ASTM A653/A653M, G235 (Z700) coating][polymer-coated galvanized steel][or][stainless steel, Grade 304][Stainless steel, Grade 316]<Insert material>**.
- B. Frame Material: **[Galvanized steel, ASTM A653/A653M, G235 (Z700) coating][polymer-coated galvanized steel][stainless steel, Grade 304][Stainless steel, Grade 316][materials to match casing]<Insert material>**.
- C. Hardware: **[Galvanized][or][stainless]** steel.
- D. Joints and Seams: Sealed watertight.
- E. Welded Connections: Sealed watertight**[by continuous welds]**.

2.5 COLLECTION BASIN

- A. Factory-Assembled Collection Basin:
 - 1. Material: **[Galvanized steel, ASTM A653/A653M, G235 (Z700) coating][Polymer-coated galvanized steel][Stainless steel, Grade 304][Stainless steel, Grade 316]<Insert material>**.
 - 2. Hardware: **[Galvanized][or][stainless]** steel.
 - 3. Joints and Seams: Sealed watertight.
 - 4. Welded Connections: Sealed watertight**[by continuous welds]**.
 - 5. Removable**[stainless-steel]** strainer with openings smaller than nozzle orifices.
 - 6. Overflow and drain connections.
 - 7. Makeup-water connection.
 - 8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.
 - 9. Basin Sweeper Distribution Piping and Nozzles:
 - a. Pipe Material: **[PVC]<Insert material>**, Schedule 40 or heavier, treated with UV inhibitors and intended for continuous exposure to direct sunlight with degradation.
 - b. Nozzle Material: **[Plastic]<Insert material>**.
 - c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.
 - d. Basin penetrations sealed watertight.
 - e. Field Connections: Threaded or flanged, depending on pipe size. Threaded for sizes through **<Insert pipe size>** and flanged for larger sizes.

2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

- A. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
- B. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:
 - 1. Enclosures: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
 - 2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to **[control makeup-water valve][control makeup-water valve and low-level alarm][control water makeup valve and low- and high-level alarms][control makeup-water valve, low- and high-level alarms, and output for shutoff of pump on low level]**.
 - 3. Electrode Probes: Stainless steel.
 - 4. Water-Stilling Chamber: **[Corrosion-resistant material][FRP][galvanized steel][PVC pipe][stainless steel, Grade 304][stainless steel, Grade 316]<Insert material>**.

5. Makeup Water Valve:
 - a. Slow-closing[**with stainless-steel body**].
 - b. Valve actuator controlled and powered through level controller in response to water-level set point.
 - c. Actuator Enclosure: NEMA 250, [Type 4][Type 4X]<Insert Type>.
 - d. Fail Position: [Closed][Open][Last].
 - e. Action: [Two position][or][modulating].
6. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.7 COLLECTION BASIN HEATER

- A. Electric Heater:
 1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
 2. Heater Control Panel: Mounted on the side of each cooling tower cell.
 3. Enclosure: NEMA 250, [Type 3R][Type 4][Type 4X]<Insert Type>.
 4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
 5. Control-circuit transformer with primary and secondary side fuses.
 6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
 7. Single-point, field-power connection to a [fused disconnect switch][nonfused disconnect switch][circuit breaker] and heater branch circuiting complying with NFPA 70.
 8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures; except, connections to each electric basin heater shall be liquidtight conduit.
 - a. Raceway shall be corrosion-resistant [stainless steel][or][PVC-coated steel].
- B. Hot-Water-Coil Heater: Manufacturer's standard heater with indicated capacity.
- C. Steam-Coil Heater: Manufacturer's standard heater with indicated capacity.
- D. Steam-Injector Heater: Manufacturer's standard offering heater with indicated capacity.

2.8 PRESSURIZED DISTRIBUTION NETWORK

- A. Main header and lateral branch piping designed for even distribution over fill and heat-exchanger coils throughout the entire flow range without the need for balancing valves and for connecting individual, easily removable, nonclogging spray nozzles.
- B. Pipe Material: [Schedule 40 PVC]<Insert material>.
- C. Spray Nozzle Material: [Plastic][Polypropylene][or][PVC]<Insert material>.
- D. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

2.9 HEAT-EXCHANGER COILS

- A. Tube and Tube Sheet Materials: **[Copper tube with stainless-steel tube sheet][stainless-steel tube and tube sheet][or][carbon-steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication]**.
- B. Heat-Exchanger Arrangement:
 - 1. **[Serpentine tubes][serpentine tubes with removable cover plate on inlet and outlet headers][or][straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube]**; and sloped for complete drainage of fluid by gravity.
 - 2. Tubes with extended surface fins if required to achieve performance indicated.
 - 3. Multiple Separate Circuits: Separate circuits to achieve multiple isolated loops as required by application.
- C. ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.
- D. Field Piping Connections: Vent, supply, and return **[suitable for mating to ASME B16.5, Class 150 flange]**.

2.10 DRIFT ELIMINATORS

- A. Material: **[PVC]<Insert material>**, with maximum flame-spread index of **[5][25]<Insert number>** according to ASTM E84.
- B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
- C. Arrangement: Multiple, easily removable sections.
- D. Configuration: Multipass, designed and tested to reduce water carryover to **[0.001]<Insert number>** percent of design flow rate indicated.
- E. Hardware: **[Galvanized][or][stainless]** steel.

2.11 AIR INLET

- A. **[Removable]**Air-Intake Screens:
 - 1. **[Galvanized][Polymer-coated, galvanized][Stainless]**-steel wire mesh, with openings of size sufficient to not restrict airflow or impact performance.
 - 2. Segmented into manageable individual sections arranged to facilitate independent removal of each section without disturbing adjoining sections.
- B. Hardware: **[Galvanized][or][stainless]** steel.

2.12 FAN AND DRIVE ASSEMBLY

- A. Axial Fans: Factory balanced **[after assembly]**.

1. Blade Material: **[Aluminum][or][galvanized steel]<Insert material>**.
 2. Hub Material: **[Aluminum][or][galvanized steel]<Insert material>**.
 3. Fan Shaft: Steel, coated to resist corrosion.
 4. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**. Bearings designed for an L-10 life of **[40,000][50,000][100,000]<Insert value>** hours.
 5. Bearing Grease Fittings: Extended lubrication lines to an easily accessible location.
- B. Centrifugal Fans: Double-width, double-inlet, forward-curved blades; statically and dynamically balanced at the factory[**after assembly**].
1. Cooling Tower Cell Fan Assembly: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
 2. Fan Wheel and Housing Materials: Hot-dip galvanized steel.
 3. Fan Shaft: Steel, coated to resist corrosion.
 4. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**. Bearings designed for an L-10 life of **[40,000][50,000][100,000]<Insert value>** hours.
 5. Bearing Grease Fittings: Extended lubrication lines to an easily accessible location.
 6. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
- C. Belt Drives:
1. Service Factor: **[1.5]<Insert value>** based on motor nameplate horsepower.
 2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
 3. Belt:
 - a. Multiple V-belt design with a matched set of[**cogged**] belts.
 - b. One-piece, multigrooved, solid-back belt.
 4. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
 5. Belt-Drive Guard: Comply with OSHA regulations.
 6. Two-Motor, Single-Fan Drive:
 - a. Two single-speed motors per cooling tower cell fan assembly; one sized for full speed and load and the other sized for **[67][100]<Insert number>** percent of full-load speed.
 - b. Each motor shall have belt drive and be configured for operation when other motor fails.
 - c. Controls and wiring same as two-speed, two-winding motor.
- D. Fan Motors:
1. Comply with NEMA MG 1 unless otherwise indicated.
 2. Description: NEMA MG 1, **[Design B]<Insert design>**, as required to comply with capacity and torque characteristics; medium induction motor.
 3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
 4. Motor Enclosure: **[Totally enclosed][totally enclosed air-over (TEAO)][or][totally enclosed fan cooled (TEFC)][and with epoxy or polyurethane finish]**.
 5. Rotor: Random wound, squirrel cage.
 6. Energy Efficiency: **[Comply with ASHRAE/IES 90.1][NEMA Premium Efficient]**.
 7. Service Factor: **[1.15]<Insert value>**.

8. Temperature Rise: **[Match][One class lower than]<Insert requirements>** insulation rating.
9. Insulation: **[Class F][Class H]<Insert class>**.
10. Variable-Speed Motors: Inverter-duty rated according to NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
11. Motor Location: Mounted outside of cooling tower airstream.
12. Severe-Duty Rating:
 - a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
 - b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C.)**
 - c. Internal Heater: Automatically energized when motor is de-energized.
 - d. Complying with IEEE 841.
13. Motor Base: Adjustable, or other suitable belt-tensioning provisions.
14. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than **[0.5]<Insert value>** percent of motor nameplate horsepower.

E. Hardware: **[Galvanized][or][stainless]** steel.

2.13 AIR DISCHARGE

A. Discharge Hood:

1. Hood Configuration: **[Tapered][Straight]**; totally surrounding heat exchanger; pressurized distribution system and drift eliminators; constructed of same material as casing; and having factory-installed **[insulation and]**access doors.
2. Discharge Dampers: Positive-closure, automatic, isolation dampers constructed of **[aluminum][galvanized steel][stainless steel]<Insert material>**, with corrosion-resistant linkages and electric actuators with NEMA 250, Type 4X enclosure.
 - a. If not provided with factory controls, field-connect provisions for electrical power and controls to open dampers when pump is energized, and close dampers when pump is de-energized.
3. Capacity-Control Dampers: **[Aluminum][Galvanized-steel][Stainless-steel]<Insert material>** dampers, with corrosion-resistant linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.
 - a. If not provided with factory controls, provide field power and controls to operate dampers when pump is energized, and close dampers when pump and fan is de-energized.

B. Hardware: **[Galvanized][or][stainless]** steel.

2.14 RECIRCULATING-WATER DISTRIBUTION SYSTEM

- A. Pump: Close-coupled, single-stage, **[bronze-fitted]**centrifugal pump with mechanical seal; suitable for outdoor service. Factory install pump with following:
1. Redundant Pump: Same performance as required for primary pump; easily switched and maintained while cooling tower remains operating.

2. Flanges at pump connections to piping.
3. Strainer[, **with blowdown isolation valve,**] installed in piping on suction side of pump.
4. Flow-balancing valve in piping on discharge side of pump.

B. Pump Motor:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, [**Design B**]<Insert design>, as required to comply with capacity and torque characteristics; medium induction motor.
3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: [**Open dripproof**][or][**totally enclosed**][**and with epoxy or polyurethane finish**].
5. Rotor: Random wound, squirrel cage.
6. Energy Efficiency: [**Comply with ASHRAE/IES 90.1**][**NEMA Premium Efficient**].
7. Service Factor: [**1.15**]<Insert value>.
8. Temperature Rise: [**Match**][**One class lower than**]<Insert requirements> insulation rating.
9. Insulation: [**Class F**][**Class H**]<Insert class>.
10. Severe-Duty Rating:
 - a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
 - b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).**
 - c. Internal Heater: Automatically energized when motor is de-energized.
 - d. Complying with IEEE 841.

C. Piping:

1. Interconnecting collection basin to pump and pressurization distribution system.
 - a. Design delegated to manufacturer.
 - b. External to and supported from cooling tower casing and frame.
 - c. Material: [**Corrosion-resistant**][**PVC**]<Insert material>.
 - d. Install flanges at connections to collection basin and pressurized distribution system.
 - e. Drain connection with isolation valve at piping low point if piping does not drain directly into collection basin.
2. Field installed for connection to remotely installed pump and water storage that are not furnished with cooling tower.

2.15 ELECTRICAL POWER

- A. Factory Furnish for Field Installation: A [**disconnect switch**][**motor controller**][**variable-frequency controller**] for each fan motor and a [**disconnect switch**][**motor controller**] for each pump motor.
- B. Factory Install: A [**disconnect switch**][**motor controller**][**variable-frequency controller**] for each fan motor and a [**disconnect switch**][**motor controller**] for each pump motor.
 1. Locate in a convenient and field-accessible location within sight of motor.
 2. Installation shall comply with NFPA 70.
 3. Wire, Conduit, and Enclosures:
 - a. Minimum Conduit Size: [**0.75 inch (20 mm)**]<Insert size>.



- b. Materials: Corrosion resistant[**and constructed of stainless steel or PVC coated steel**].
- c. Motor Termination: Liquidtight conduit, not to exceed **36 inches (900 mm)** long.
- d. Supports: Support, conduits boxes, and enclosures using corrosion-resistant fastening hardware[**constructed of stainless steel**].
- e. Wire:
 - 1) Copper, rated for 600-V, solid wire for size [No. 10 AWG]<Insert wire size> and smaller and stranded wire for larger sizes.
 - 2) Minimum Wire Size: [No. 12 AWG]<Insert wire size>.
 - 3) Each circuit shall have a ground wire.
 - 4) Install wire in conduit.
- f. Boxes, Condulets, and Enclosures: NEMA 250, [Type 3R][Type 4][Type 4X].

C. Disconnect Switches:

- 1. Specification Grade; "Heavy-Duty Type," "quick make," "quick break" construction.
- 2. Three pole [fused][or][nonfused].
- 3. 600-V rated.
- 4. Minimum SCCR: As required by electrical power distribution system, but not less than [42,000][65,000]<Insert value> A.
- 5. Enclosure: NEMA 250, [Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]<Insert Type>.
- 6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
- 7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
- 8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
- 9. Include a solid neutral as required by authorities having jurisdiction.
- 10. Include a ground lug for ground wire termination.
- 11. Operating handle shall be lockable in open position.
- 12. Horsepower rated.
- 13. Feed through or double lugged.

D. Motor Controllers:

- 1. NEMA ICS 2, Class A, full-voltage, non-reversing motor-rated controller.
- 2. Configured for control of single- or multi-speed motors.
- 3. Enclosure: NEMA 250, [Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]<Insert Type>, with hinged full-front access door with lock and key.
- 4. Externally Operated[, **Door-Interlocked**] Disconnect: [**Fused disconnect switch**][**Nonfused disconnect switch**][**Circuit breaker**] with lockable handle.
- 5. SCCR: As required by electrical power distribution system, but not less than [42,000][65,000]<Insert value> A.
- 6. Hand-Off-Auto Switch: Mounted on face of enclosure.
- 7. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
- 8. Control Relays: Time-delay relays.
- 9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
- 10. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
- 11. Number-of-Starts Counter: Numerical readout on face of enclosure.

E. Variable-Frequency Controllers:

- 1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage

- and frequency.
2. Enclosure: Unit mounted, NEMA 250, **[Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]<Insert Type>**, with hinged full-front access door with lock and key.
3. Externally Operated[, **Door-Interlocked**] Disconnect: **[Fused disconnect switch][Nonfused disconnect switch][Circuit breaker]** with lockable handle.
4. SCCR: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert value> A**.
5. Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBTs); suitable for variable-torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
9. Operating Requirements:
 - a. Input AC Voltage Tolerance: **[10]<Insert number>** percent.
 - b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - c. Capable of driving full motor load, without derating.
 - d. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - e. Minimum Displacement Primary-Side Power Factor: 95 percent.
 - f. Overload Capability: 1.05 times the full-load current for seven seconds.
 - g. Starting Torque: As required by fan and motor drive assembly.
 - h. Speed Regulation: 1 percent.
 - i. Speed Range: 10:1 speed range.
 - j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
 - k. Capable of being restarted into a motor, coasting in either the forward or reverse direction without tripping.
10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
 - a. Overtemperature.
 - b. Short circuit at controller output.
 - c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
 - d. Open circuit at controller output.
 - e. Input undervoltage.
 - f. Input overvoltage.
 - g. Loss of input phase.
 - h. Reverse phase.
 - i. AC line-switching transients.
 - j. Instantaneous overload, line to line or line to ground.
 - k. Sustained overload exceeding 100 percent of controller rated current.
 - l. Starting a rotating motor.
 - m. **<Insert features>**.
12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
13. Automatic Reset and Restart:
 - a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.

- b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
- 14. Visual Indication: On face of controller; indicating the following conditions:
 - a. Power on.
 - b. Run.
 - c. Overcurrent and overvoltage.
 - d. Motor speed (percent).
 - e. Various faults with alarm status.
 - f. Input kilovolt amperes.
 - g. Power factor.
 - h. Input kilowatts and kilowatt-hours.
 - i. Three-phase input and output voltage.
 - j. Three-phase input and output current.
 - k. Output frequency.
 - l. Elapsed operating time (hours).
 - m. Diagnostic and service parameters.
 - n. **<Insert conditions>**.
- 15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
- 16. Control Signal Interface: A minimum of **[two]<Insert number>** analog inputs (0 to 10 V or 0/4 to 20 mA) and **[four]<Insert number>** programmable digital inputs.
- 17. Bypass Controller:
 - a. Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.
 - b. Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller, for safe servicing of variable-frequency controller.
 - c. Include "Bypass/VFC" manual selector switch on face of enclosure to provide for local operator control of preferred controller.
 - d. Include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.
 - e. Install bypass controller in same enclosure as variable-frequency controller.

2.16 CONTROLS

- A. Vibration Switch: For each fan drive.
 - 1. Enclosure: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
 - 2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
 - 3. Switch shall have manual-reset button with hardwired connection to fan motor electrical circuit.
 - 4. Switch shall have field connection for hardwired connection to control system.
 - 5. Switch shall, on sensing excessive vibration, **[signal an alarm for connection to control system and]** shut down the fan.
- B. Control Package:
 - 1. Factory installed and wired, and functionally tested at factory before shipment.
 - 2. NEMA 250, **[Type 3R][Type 4][Type 4X]** enclosure with removable, internally mount backplate.
 - 3. Control-circuit transformer with primary and secondary side fuses.

4. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
5. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature, with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
6. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
7. Collection basin water-level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve" Paragraph.
8. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Collection Basin Heater" Article.
9. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph in "Controls" Article.
10. Single-point, field-power connection to a **[fused disconnect switch][nonfused disconnect switch][circuit breaker][for each cooling tower cell]**.
 - a. Branch power circuit to each motor and electric basin heater and to controls **[with a disconnect switch or circuit breaker]**.
 - b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
11. Factory-installed wiring outside of enclosures shall be in metal raceway; except, make connections to each motor and electric basin heater with liquidtight conduit.
12. Visual indication of status and alarm **[with momentary test push button]** for each motor.
13. Audible alarm and silence switch.
14. Visual indication of elapsed run time, graduated in hours for each motor.
15. Cooling tower shall have hardware to enable control system to remotely monitor and display the following:
 - a. Operational status of each motor.
 - b. Cooling tower leaving-fluid temperature.
 - c. Fan vibration alarm.
 - d. Collection basin **[high][low][high- and low]**-water-level alarms.
 - e. **<Insert conditions to be monitored>**.

2.17 WATER TREATMENT

- A. Chemical-Free Water Treatment System: Complete factory-installed system consisting of the following:
 1. Pulsed-power technology emitting high-frequency bursts of low-energy electromagnetic fields to the recirculated water to control corrosion, bacteria, and scale.
 2. Conductivity control of electrically operated valve designed to control totally dissolved solids levels and bleed rates.
 3. Piping associated with system.
 4. Interconnecting power and control wiring installed in corrosion-resistant metal raceway.

2.18 SERVICE ACCESS

- A. Doors:
 1. Large enough for personnel to access cooling tower internal components.
 2. Doors shall be hinged with handles operable from both sides of the door.
 3. Door materials shall match casing.

4. Hinges and handles shall be [**corrosion-resistant**][**stainless steel**]<Insert material>.

- B. External Ladders with Safety Cages: [**Aluminum**][**galvanized steel**][or][**stainless-steel**]<Insert material> fixed ladders, with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
- C. External Platforms with Handrails: [**Aluminum**][**galvanized steel**][or][**stainless-steel**]<Insert material> bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
- D. Handrail: [**Aluminum**][**galvanized steel**][or][**stainless steel**]<Insert material> complete with kneerail and toeboard, around external platforms and top of cooling tower. Comply with 29 CFR 1910.23.
- E. Hardware: Galvanized steel when connecting galvanized-steel components and stainless steel when connecting other materials.

2.19 CAPACITIES AND CHARACTERISTICS

- A. Number of Cells: <Insert quantity>.
- B. Air-Inlet Arrangement: One side.
- C. Maximum Drift Loss: [**0.001**]<Insert number> percent of design water flow.
- D. Heat Exchanger:
 - 1. Fluid Type: [**Water**][**Insert Type**].
 - 2. Design Fluid Flow per Cell: <Insert gpm (L/s)>.
 - 3. Minimum Fluid Flow per Cell: <Insert gpm (L/s)>.
 - 4. Fluid Pressure Drop: <Insert psig (kPa)>.
 - 5. Fluid Pressure Rating: <Insert psig (kPa)>.
 - 6. Entering-Fluid Temperature: <Insert deg F (deg C)>.
 - 7. Leaving-Fluid Temperature: <Insert deg F (deg C)>.
 - 8. Entering-Air Wet-Bulb Temperature: <Insert deg F (deg C)>.
 - 9. Air Flow per Cell: <Insert cfm (L/s)>.
- E. Economizer Mode Performance:
 - 1. Fluid Flow per Cell: <Insert gpm (L/s)>.
 - 2. Entering-Fluid Temperature: <Insert deg F (deg C)>.
 - 3. Leaving-Fluid Temperature: <Insert deg F (deg C)>.
 - 4. Entering-Air, Wet-Bulb Temperature: <Insert deg F (deg C)>.
- F. Fan Drive Assembly:
 - 1. Type: Belt.
 - 2. Fan Motor:
 - a. Type: [**Single speed**][**Two speed, single winding**][**Two-speed, two winding**][**Variable speed**].
 - b. Motor Size per Cell: <Insert number> hp.
 - c. Full-Load Ampacity: <Insert number> A.
 - d. Minimum Circuit Ampacity: <Insert number> A.

- e. Maximum Overcurrent Protection Device: **<Insert number> A.**
- f. Electrical Characteristics: **[208][240][480]<Insert number> V ac, 3 phase, 60 Hz.**

G. Pump and Motor:

- 1. Water Flow per Cell: **<Insert gpm (L/s)>.**
- 2. Motor Size per Cell: **<Insert number> hp.**
- 3. Full-Load Ampacity: **<Insert number> A.**
- 4. Minimum Circuit Ampacity: **<Insert number> A.**
- 5. Maximum Overcurrent Protection Device: **<Insert number> A.**
- 6. Electrical Characteristics: **[120][208][240][277][480]<Insert number> V ac, [single][3] phase, 60 Hz.**

H. Sound Pressure Level: <Insert dBA> at <Insert distance in feet (m)>[when measured according to CTI ATC 128].

I. Collection Basin Heater:

- 1. Basin Water Temperature: **[40 deg F (5 deg C)]<Insert temperature>.**
- 2. Outdoor Ambient Temperature: **[0 deg F (minus 18 deg C)][Minus 20 deg F (Minus 29 deg C)]<Insert temperature>.**
- 3. Capacity per Cell: **<Insert number> kW.**
- 4. Full-Load Ampacity: **<Insert number> A.**
- 5. Minimum Circuit Ampacity: **<Insert number> A.**
- 6. Maximum Overcurrent Protection Device: **<Insert number> A.**
- 7. Electrical Characteristics: **[208][240][480]<Insert number> V ac, 3 phase, 60 Hz.**

2.20 SOURCE QUALITY CONTROL

A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS.

- 1. Allow **[Owner]<Insert entity>** access to place where cooling towers are being tested. Notify Owner in writing at least **[30]<Insert number>** days in advance of testing.
- 2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

B. Seismic Performance Testing: Shake table tested by an independent [or a factory-certified] laboratory to certify performance complies with seismic requirements indicated.

- 1. Allow **[Owner]<Insert entity>** access to place where cooling towers are being tested. Notify Owner in writing at least **[30]<Insert number>** days in advance of testing.
- 2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

C. Factory Functional Tests:

- 1. Test collection and distribution basins after assembly, and prove free of leaks.
- 2. Test factory-installed electric/electronic water-level controls for proper operation.
- 3. Test factory-installed electric basin heaters for proper operation.
- 4. Test factory-installed fan and drive assemblies for proper operation.
- 5. Test factory-installed control package for proper operation.
- 6. Test access doors to ensure smooth operation and proper fit.
- 7. **<Insert additional functional test requirements>.**
- 8. Allow **[Owner]<Insert entity>** access to place where cooling towers are being tested. Notify Owner in writing at least **[30]<Insert number>** days in advance of testing.



9. Submit report documenting tests performed and results within one week of test date.

D. Heat-Exchanger Factory Pressure and Leak Tests:

1. Pneumatically test heat-exchanger assembly while submerged under water and prove to be free of leaks.
2. Test pressure equal to **[1.5]<Insert value>** times rated pressured, but not less than **<Insert psig (kPa)>**.
3. Submit report documenting test and results.

E. Owner Travel Expenses:

1. Include cost associated with Owner travel expenses to witness testing. Total value attributed to travel expenses shall be clearly indicated.
2. Expenses shall include round-trip coach airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation, and all associated taxes and fees.
3. Exclude other incidental expenses not indicated.
4. Include travel expenses for **[one][two]<Insert number>** Owner representatives with origin of **<Insert city, state, and country>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine cooling towers before installation. Reject cooling towers that are damaged.
- B. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting cooling tower performance, maintenance, and operation.
 1. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.
 2. Verify sizes and locations of concrete bases and support structure with actual equipment.
 3. Verify sizes, locations, and anchoring attachments of structural-steel support structures.
 4. Verify sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install cooling towers on support structure.
- B. Equipment Mounting:
 1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration

Controls for HVAC."

- C. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Maintain manufacturer's recommended clearances for service and maintenance.
- E. Maintain clearances required by governing code.
- F. Loose Components: Install components, devices, and accessories furnished by manufacturer with cooling tower that are not factory mounted.
 - 1. Loose components shall be installed by **[manufacturer's factory-trained service personnel][Contractor under supervision of manufacturer's factory-trained service personnel]**.

3.3 DUCT CONNECTIONS

- A. Duct installation requirements are specified in other Sections. Drawings indicate general arrangement of ductwork and accessories.
- B. Where installing duct adjacent to cooling towers, allow space for service and maintenance.
- C. Install flexible connectors at duct connections to cooling towers.

3.4 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.
- C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.
- D. Install drain piping with valve at cooling tower drain connections and at low points in piping.
- E. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.
- F. Makeup-Water Piping:
 - 1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
 - 2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow meter, and drain connection with valve and union.
- G. Supply and Return Piping:
 - 1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 2. Connect to entering-cooling-tower connections with shutoff valve, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
 - 3. Connect to leaving-cooling-tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
 - 4. Make connections to cooling tower with a flange.



H. Basin Heater Hot-Water Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve, strainer, control valve thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
4. Make connections with a flange, union, or mechanical coupling.

I. Basin Heater Steam and Condensate Piping:

1. Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
2. Connect steam supply connection with shutoff valve, strainer, control valve, pressure gage and flow meter.
3. Connect to condensate connection with shutoff valve, strainer, and an appropriate steam trap assembly.
4. Make connections with a flange or union.

J. Basin Sweeper Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve, flow meter, and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve, flow meter, and drain connection with valve.
4. Make connections with a flange or union.

3.5 ELECTRICAL POWER CONNECTIONS

- A. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
- B. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
- C. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
- D. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least **1/2 inch (13 mm)** high. Locate nameplate where easily visible.

3.6 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.
- C. Connect control wiring between cooling tower control interface and control system for HVAC for remote

monitoring and control of cooling towers. Comply with requirements in [Section 230923 "Direct Digital Control (DDC) System for HVAC"]<Insert Section>.

- D. Install label at each termination indicating control equipment designation serving cooling tower and the I/O point designation for each control connection. Comply with requirements in Section 260553 "Identification for Electrical Systems" for labeling and identifying products and installations.

3.7 FIELD TESTING PROVISIONS

- A. Include provisions for cooling tower future field performance testing complying with [ASME PTC 23][CTI ATC 105].
- B. Include provisions in field piping for future field performance testing complying with [ASME PTC 23][CTI ATC 105].

3.8 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections: Comply with [ASME PTC 23][CTI ATC 105].
- E. Cooling towers will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.9 STARTUP SERVICE

- A. [**Engage a factory-authorized service representative to perform**][**Perform**] startup service.
- B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.
- C. Obtain performance data from manufacturer.
 - 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Clean entire unit, including basins.
 - b. Verify that accessories are properly installed.
 - c. Verify clearances for airflow and for cooling tower servicing.
 - d. Check for vibration isolation and structural support.
 - e. Lubricate bearings.
 - f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
 - g. Verify pump rotation for correct direction, vibration, cavitation, and flow, and correct

- problems.
- h. Adjust belts to proper alignment and tension.
- i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
- j. Check vibration switch setting. Verify operation.
- k. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
- l. Verify operation of basin heater and control.
- m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
- n. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.10 ADJUSTING

- A. Set and balance water flow to each tower inlet.
- B. Adjust water-level control for proper operating level.
- C. Adjust basin heater control for proper operating setpoint.

3.11 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain cooling towers.
 - 1. Video record the training sessions.
 - 2. Instructor shall be factory trained and certified.
 - 3. Perform not less than **[eight]<Insert number>** hours of training.
 - 4. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
 - 5. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 - 6. Obtain Owner sign-off that training is complete.
 - 7. Owner training shall be held at Project site.

END OF SECTION 23 65 13 16

SECTION 23 65 14 13 - OPEN-CIRCUIT, INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes factory-assembled, open-circuit, induced-draft, counterflow cooling towers.

1.2 DEFINITIONS

- A. SCCR: Short-circuit current rating.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, pressure drop, fan performance data, rating at selected points indicated, and furnished specialties and accessories.
 - 2. Maximum flow rate.
 - 3. Minimum flow rate.
 - 4. Pressure required at cooling tower supply piping connections.
 - 5. Pressure required at basin heater supply piping connections.
 - 6. Pressure required at collection basin sweeper supply piping connections.
 - 7. Drift loss as percent of design flow rate.
 - 8. Volume of water in suspension for purposes of sizing remote storage.
 - 9. Sound:
 - a. Sound pressure levels for operation with fan off, fan at minimum speed, and design speed. If sound requirements are indicated at a specific distance, submit performance using same distance for comparative analysis.
 - b. Sound power levels in eight octave bands for operation with fans off, fans at minimum speed, and design speed.
 - 10. Performance curves for the following:
 - a. Varying entering-water temperatures from design to minimum in [one][five]<Insert number>-degree temperature increments.
 - b. Varying ambient wet-bulb temperatures from design to minimum in [one][five]<Insert number>-degree temperature increments.
 - c. Varying water flow rates from design to minimum in increments of [10]<Insert number> percent of flow rate difference between design and minimum flow rates.
 - d. Varying fan operation from design to minimum speed in [5][10]<Insert number> percent speed increments, and with fan off.
 - 11. Fan airflow at design conditions, brake horsepower, and drive losses (indicated in horsepower and percent of brake horsepower).
 - 12. Fan motor electrical characteristics including, but not limited to, speed, voltage, phase, hertz, amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
 - 13. Electrical power requirements for each cooling tower component requiring power.

B. Shop Drawings:

1. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
2. Assembled unit dimensions.
3. Diagram showing each separate piece requiring field assembly.
4. Shipped sub-assembly dimensions and weights for field assembly.
5. Assembled unit weight without water.
6. Operating weight and load distribution.
7. Unit vibration isolation[**and seismic controls**].
8. Required clearances for maintenance and operation.
9. Sizes and dimensioned locations of piping and wiring connections.
10. Diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Design Calculations: Calculate requirements for selecting vibration isolators [**and seismic restraints**][**and wind restraints**] and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Drawings on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Structural supports.
 - b. Piping roughing-in requirements.
 - c. Conduit and wiring roughing-in requirements for controls and electrical power, including spaces reserved for controls and electrical equipment.
 - d. Access requirements, including working clearances for controls and electrical equipment, and service clearances. Mark and label clearances.
2. Drawings showing plans, sections, and elevation views, drawn to scale of at least **<Insert scale>**.
3. Each view to show screened background with the following:
 - a. Structural grids.
 - b. Adjacent walls, floors, and roofs.
 - c. Equipment and products of other trades that are located in vicinity of cooling towers and are part of final installation, such as, controls, power, lighting, fire-suppression systems, and plumbing systems.

B. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their

installation requirements.

- C. Product Certificates: For certification required in "Quality Assurance" Article.
- D. Field Test Reports: Include startup service reports.
- E. Source quality-control reports.
- F. Field quality-control reports.
- G. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.
- B. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Belts:
 - 1. Furnish **[one]<Insert number>** set(s) of matching belts for each unique belt configuration and size furnished.
- B. Tool Kit:
 - 1. A tool kit specially designed by cooling tower manufacturer for use in servicing cooling tower(s) furnished.
 - 2. Special tools required to service components not readily available to Owner service personnel in performing routine maintenance.
 - 3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Cooling Tower Tool Kit." Text size shall be at least **1 inch (25 mm)** high.
 - 4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least **1/2 inch (13 mm)** high.
- C. Touchup Coating: **[32-oz. (1-L)]<Insert volume>** container of paint coating used. Label outside of container with detailed description of coating to allow for procurement of a matching coating in the future.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: **[Certified by CTI][An NRTL]**.
- B. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.
- C. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."



1.8 DELIVERY, STORAGE, AND HANDLING

- A. Coordinate requirements for multi-piece assembly for shipment. Limit the number of separate pieces for field installation to as few as possible.
- B. If factory assembly of multiple pieces is required for testing or other reasons, disassemble cooling tower into major assemblies as required by installation before packaging for shipment.
 - 1. Clearly label each separate package with a unique designation and include with assembly instructions for each complete cooling tower.
 - 2. Install seals on gear-drive assemblies to eliminate oil leakage during shipment if shipped with oil.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:
 - 1. All components of cooling tower.
 - 2. Fan assembly including fan, drive, and motor.
 - 3. **<Insert components requiring extended warranty>.**
 - 4. Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OPEN-CIRCUIT, INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Amcot Cooling Tower Corp.]**
 - 2. **[Baltimore Aircoil Company]**
 - 3. **[Delta Cooling Towers, Inc.]**
 - 4. **[EVAPCO, Inc]**
 - 5. **[Marley; a brand of SPX Cooling Technologies, Inc.]**
 - 6. **[Protec Cooling Towers, Inc]**
 - 7. **[Thermal Care, Inc.]**
 - 8. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Amcot Cooling Tower Corp.]**
 - 2. **[Baltimore Aircoil Company]**
 - 3. **[Delta Cooling Towers, Inc.]**
 - 4. **[EVAPCO, Inc]**
 - 5. **[Marley; a brand of SPX Cooling Technologies, Inc.]**
 - 6. **[Protec Cooling Towers, Inc]**
 - 7. **[Thermal Care, Inc.]**
 - 8. **<Insert manufacturer's name>**

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cooling tower support structure[**and seismic restraints**][**and wind restraints**], including comprehensive engineering analysis.
- B. Structural Performance: Cooling tower and support structure shall withstand the effects of loads and stresses within limits and under conditions indicated according to [ASCE/SEI 7][the IBC][governing code]<Insert requirement>.
- C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7]<Insert requirement>.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: [1.5][1.0].
 - 3. Component Amplification Factor: <Insert value>.
 - 4. Component Response Modification Factor: <Insert value>.
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Operation Following Loss of Normal Power:
 - 1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
 - 2. Include means and methods required to satisfy requirement even if not explicitly indicated.
- G. Vibration:
 - 1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry-standard requirements for cooling towers.
 - 2. Critical speed shall be at least 115 percent of design speed.

2.3 DESIGN ARRANGEMENT

- A. Counterflow design with airflow from all sides and induced-draft, top-mounted axial fan and pressurized pipe distribution.

2.4 CASING AND FRAME

- A. Casing Material: [FRP with UV inhibitors][HDPE with UV inhibitors][Galvanized steel, ASTM A653/A653M, G210 (Z600) coating][Galvanized steel, ASTM A653/A653M, G235 (Z700) coating][Polymer-coated galvanized steel][Stainless steel, Grade 304][Stainless steel, Grade 316]<Insert material>.



- B. Frame Material: **[FRP with UV inhibitors][HDPE with UV inhibitors][galvanized steel, ASTM A653/A653M, G210 (Z600) coating][galvanized steel, ASTM A653/A653M, G235 (Z700) coating][polymer-coated galvanized steel][stainless steel, Grade 304][stainless steel, Grade 316][or][materials to match casing]<Insert material>**.
- C. Hardware: **[Galvanized][or][stainless]** steel.
- D. Joints and Seams: Sealed watertight.
- E. Welded Connections: Sealed watertight **[by continuous welds]**.

2.5 COLLECTION BASIN

- A. Field-Constructed Collection Basin: Configure tower without a factory-assembled collection basin for installation and operation with a field-constructed collection basin.
- B. Factory-Assembled Collection Basin:
 - 1. Material: **[FRP with UV inhibitors][HDPE with UV inhibitors][Galvanized steel, ASTM A653/A653M, G210 (Z600) coating][Galvanized steel, ASTM A653/A653M, G235 (Z700) coating][Polymer-coated galvanized steel][Stainless steel, Grade 304][Stainless steel, Grade 316]<Insert material>**.
 - 2. Hardware: **[Galvanized][or][stainless]** steel.
 - 3. Joints and Seams: Sealed watertight.
 - 4. Welded Connections: Sealed watertight **[by continuous welds]**.
 - 5. Removable **[stainless-steel]** strainer with openings smaller than nozzle orifices.
 - 6. Overflow and drain connections.
 - 7. Makeup-water connection.
 - 8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.
 - 9. Removable equalization flume plate between adjacent cells of multiple-cell towers.
 - 10. Equalizer connection for field-installed equalizer piping configured to mate to ASME B16.5, Class 150 flange.
 - 11. Basin Sweeper Distribution Piping and Nozzles:
 - a. Pipe Material: **[PVC][or][CPVC]<Insert material>**, Schedule 40 or heavier, treated with UV inhibitors and intended for continuous exposure to direct sunlight with degradation.
 - b. Nozzle Material: **[Plastic]<Insert material>**.
 - c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.
 - d. Basin penetrations sealed watertight.
 - e. Field Connections: Threaded or flanged depending on pipe size. Thread for sizes through **<Insert pipe size>** and flanged for larger sizes.

2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

- A. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
- B. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:
 - 1. Enclosures: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
 - 2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to **[control makeup-water valve][control makeup-water valve and low-level alarm][control makeup-water valve and low- and high-level alarms][control makeup-water**

- valve, low- and high-level alarms, and output for shutoff of pump on low level].
- 3. Electrode Probes: Stainless steel.
- 4. Water Stilling Chamber: **[Corrosion-resistant material][FRP][Galvanized steel][PVC pipe][Stainless steel, Grade 304][Stainless steel, Grade 316]<Insert material>**.
- 5. Makeup-Water Valve:
 - a. Slow closing **[with stainless-steel body]**.
 - b. Valve actuator controlled and powered through level controller in response to water-level set point.
 - c. Actuator Enclosure: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
 - d. Fail Position: **[Closed][Open][Last]**.
 - e. Action: **[Two position][or][modulating]**.
- 6. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

C. Ultrasonic Collection Basin Water-Level Controller with Makeup-Water Valve:

- 1. Enclosure: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
- 2. Controller:
 - a. Ultrasonic level sensor/transmitter with local display of measured value.
 - b. Factory wired to terminal strip.
 - c. Control makeup-water valve in response to water-level set point.
 - d. Adjustable level, alarm signal through relay closure **[for connection to control system]**.
 - e. Continuous level indication through a 4- to 20-mA signal **[for connection to control system]**.
- 3. Water Stilling Chamber: **[Corrosion-resistant material][FRP][Galvanized steel][PVC pipe][Stainless steel, Grade 304][Stainless steel, Grade 316]<Insert material>**.
- 4. Makeup-Water Valve:
 - a. Slow closing **[with stainless-steel body]**
 - b. Valve actuator controlled and powered through level controller in response to water-level set point.
 - c. Actuator Enclosure: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
 - d. Fail Position: **[Closed][Open][Last]**.
 - e. Action: **[Two position][or][modulating]**.
- 5. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.7 COLLECTION BASIN HEATER

A. Electric Heater:

- 1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
- 2. Heater Control Panel: Mounted on the side of each cooling tower cell.
- 3. Enclosure: NEMA 250, **[Type 3R][Type 4][Type 4X]<Insert Type>**.
- 4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
- 5. Control-circuit transformer with primary and secondary side fuses.
- 6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
- 7. Single-point, field-power connection to a **[fused disconnect switch][nonfused disconnect switch][circuit breaker]** and heater branch circuiting complying with NFPA 70.

8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except connections to each electric basin heater shall be liquidtight conduit.

a. Raceway shall be corrosion-resistant [**stainless steel**][or][**PVC coated steel**].

B. Hot-Water-Coil Heater: Manufacturer's standard heater with indicated capacity.

C. Steam-Coil Heater: Manufacturer's standard heater with indicated capacity.

D. Steam-Injector Heater: Manufacturer's standard heater with indicated capacity.

2.8 PRESSURIZED DISTRIBUTION NETWORK

A. Main header and lateral branch piping designed for even distribution over fill throughout the entire flow range without the need for balancing valves and for connecting individual, easily removable, non-clogging spray nozzles.

B. Pipe Material: [**Fiberglass**][**Schedule 40 PVC**][or][**galvanized steel**]<Insert material>.

C. Spray Nozzle Material: [**Plastic**][**polypropylene**][or][**PVC**]<Insert material>.

D. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

2.9 FILL

A. Materials: PVC, with maximum flame-spread index of [**5**][**25**]<Insert value> according to ASTM E84.

B. Minimum Thickness: [**15 mils (0.4 mm)**][**20 mils (0.5 mm)**]<Insert value>, before forming.

C. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.

D. Fill Material Operating Temperature: Suitable for entering-water temperatures up through [**120 deg F (49 deg C)**]<Insert temperature>.

E. Hardware: [**Galvanized**][or][**stainless**] steel.

2.10 DRIFT ELIMINATORS

A. Material: [**FRP**][**PVC**][**FRP or PVC**]<Insert material>; with maximum flame-spread index of [**5**][**25**]<Insert number> according to ASTM E84.

B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

C. Configuration: Multipass, designed and tested to reduce water carryover to [**0.001**][**0.005**]<Insert number> percent of design flow rate indicated.

D. Hardware: [**Galvanized**][or][**stainless**] steel.

2.11 AIR INLET

A. Air-Intake Louvers:

1. Material: **[FRP][PVC][Matching casing]<Insert material>**.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Multiple, easily removable sections arranged to uniformly direct air into cooling tower, to minimize air resistance, to block direct sunlight, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

B. **[Removable]**Air-Intake Screens:

1. **[Galvanized][Polymer-coated, galvanized][Stainless]**-steel wire mesh with openings of size sufficient to not restrict airflow or impact performance.
2. Segmented into manageable individual sections arranged to facilitate independent removal of each section without disturbing adjoining sections.

C. Hardware: **[Galvanized][or][stainless]** steel.

2.12 FAN AND DRIVE ASSEMBLY

A. Axial Fan: Balanced at the factory[**after assembly**].

1. Blade Material: **[Aluminum][FRP][or][galvanized steel]<Insert material>**.
2. Hub Material: **[Aluminum][FRP][or][galvanized steel]<Insert material>**.
3. Blade Pitch: Field adjustable.
4. Fan Shaft: **[Corrosion resistant][Stainless steel]<Insert material>**.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**. Bearings designed for an L-10 life of **[40,000][50,000][100,000]<Insert value>** hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

B. Belt Drive:

1. Service Factor: **[1.5]<Insert value>** based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt:
 - a. Multiple V-belt design with a matched set of **[cogged]** belts.
 - b. One-piece, multigrooved, solid-back belt.
4. Belt Material: Oil resistant, non-static conducting, and constructed of neoprene polyester cord.
5. Belt-Drive Guard: Comply with OSHA regulations.
6. Two-Motor, Single-Fan Drive:
 - a. Two single-speed motors per fan, one sized for full speed and load and the other sized for **[67]<Insert number>** percent of full-load speed.
 - b. Each motor shall have belt drive and be configured for operation when other motor fails.
 - c. Controls and wiring same as two-speed, two-winding motor.

C. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.

D. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI

STD 111. Motor and gear drive shall be aligned before shipment.

1. Gear Drive and Coupling Service Factor: **[2.0]<Insert value>** based on motor nameplate horsepower.
2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse. Able to operate throughout entire speed range from design speed indicated down to **[10][20]<Insert value>** of design speed.
5. Drive-to-Motor Connection: **[Close coupled to motor using a flexible coupling.][Connected to motor located outside of cooling tower casing by a full-floating drive shaft.]**
6. Drive Shaft Material: **[Corrosion resistant][Stainless steel]**, and fitted with flexible couplings on both ends.
7. Drive Guards: Exposed shaft and couplings shall have guards according to OSHA regulations.
8. Extend oil fill, drain, and vent to outside of cooling tower casing using **[galvanized-steel][or][stainless-steel]** piping. Include oil-level sight glass.

E. Fan Motor:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, **[Design B]<Insert design>**, as required to comply with capacity and torque characteristics; medium induction motor.
3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: **[Totally enclosed][Totally enclosed air-over (TEAO)][Totally enclosed fan-cooled (TEFC)][and with epoxy or polyurethane finish].**
5. Rotor: Random-wound, squirrel cage.
6. Energy Efficiency: **[Comply with ASHRAE/IES 90.1][NEMA Premium Efficient].**
7. Service Factor: **[1.15]<Insert value>**.
8. Temperature Rise: **[Match][One class lower than]<Insert requirements>** insulation rating.
9. Insulation: **[Class F][Class H]<Insert class>**.
10. Variable-Speed Motors: Inverter-duty rated per NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
11. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
12. Severe-Duty Rating:
 - a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
 - b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**.
 - c. Internal Heater: Automatically energized when motor is de-energized.
 - d. Complying with IEEE 841.
13. Motor Base: Adjustable, or other suitable belt-tensioning provisions.
14. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than **[0.5]<Insert number>** percent of motor nameplate horsepower.

F. Hardware: **[Galvanized][or][stainless]** steel.

2.13 AIR DISCHARGE

A. Low-Profile Fan Discharge Stack:

1. Manufacturer's standard low-profile design.
2. Material: **[Material to match casing][FRP][Galvanized steel][Polymer-coated, galvanized steel][Stainless steel]<Insert material>**.
3. Stack Extension: Fabricated to extend above fan deck **<Insert distance>** unless otherwise indicated.
4. Stack Termination: Wire-mesh, **[galvanized-steel][polymer-coated, galvanized-steel][or][stainless-steel]<Insert material>** screens; segmented into multiple removable pie sections and complying with OSHA regulations.

B. Velocity Recovery Fan Discharge Stack:

1. Design: Tapered and expanded for velocity recovery and improved energy efficiency.
2. Material: FRP or material matching casing.
3. Stack Height: Fabricated to extend above fan deck at least **[5 feet (1.5 m)]<Insert dimension>** unless otherwise indicated.
4. Service Access: Fabricated of multiple segments to facilitate removal of fan and drive components from overhead.
5. Stack Termination: Wire-mesh, **[galvanized-steel][polymer-coated, galvanized-steel][or][stainless-steel]<Insert material>** screens; segmented into multiple removable pie sections and complying with OSHA regulations.

C. Hardware: **[Galvanized][or][stainless]** steel.

2.14 ELECTRICAL POWER

A. Factory Furnish for Field Installation: A **[disconnect switch][motor controller][variable-frequency controller]** for each fan motor.

B. Factory Install: A **[disconnect switch][motor controller][variable-frequency controller]** for each fan motor.

1. Locate in a convenient and field-accessible location within sight of motor.
2. Installation shall comply with NFPA 70.
3. Wire, Conduit, and Enclosures:
 - a. Minimum Conduit Size: **[0.75 inch (20 mm)]<Insert size>**.
 - b. Materials: Corrosion resistant **[and constructed of 300L series stainless steel or PVC coated steel]**.
 - c. Motor Termination: Liquidtight conduit, not to exceed **36 inches (900 mm)** long.
 - d. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware **[constructed of stainless steel]**.
 - e. Wire:
 - 1) Copper, rated for 600-V, solid wire for size **[No. 10 AWG]<Insert wire size>** and smaller and stranded wire for larger sizes.
 - 2) Minimum Wire Size: **[No. 12 AWG]<Insert wire size>**.
 - 3) Each circuit shall have a ground wire.
 - 4) Install wire in conduit.
 - f. Boxes, Condulets, and Enclosures: NEMA 250, **[Type 3R][Type 4][Type 4X]**.

C. Disconnect Switches:

1. Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.
2. Three pole, **[fused][or][nonfused]**.
3. 600-V rated.
4. Minimum SCCR: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert value> A**.
5. Enclosure: NEMA 250, **[Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]<Insert Type>**.
6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
9. Include a solid neutral as required by authorities having jurisdiction.
10. Disconnect switch shall have a ground lug for ground wire termination.
11. Operating handle shall be lockable in open position.
12. Horsepower rated.
13. Feed through or double lugged.

D. Motor Controllers:

1. NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.
2. Configured for control of single- or multispeed motors.
3. Enclosure: NEMA 250, **[Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]<Insert Type>**, with hinged full-front access door with lock and key.
4. Externally Operated[, **Door-Interlocked**] Disconnect: **[Fused disconnect switch][Nonfused disconnect switch][Circuit breaker]** with lockable handle.
5. SCCR: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert value> A**.
6. Hand-Off-Auto Switch: Mounted on face of enclosure.
7. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
8. Control Relays: Time-delay relays.
9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
10. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
11. Number-of-Starts Counter: Numerical readout on face of enclosure.

E. Variable-Frequency Controllers:

1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
2. Enclosure: Unit mounted, NEMA 250, **[Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]<Insert Type>**, with hinged full-front access door with lock and key.
3. Externally Operated[, **Door-Interlocked**] Disconnect: **[Fused disconnect switch][Nonfused disconnect switch][Circuit breaker]** with lockable handle.
4. Minimum SCCR: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert value> A**.
5. Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.

9. Operating Requirements:
 - a. Input AC Voltage Tolerance: [10]<Insert number> percent.
 - b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - c. Capable of driving full motor load, without derating.
 - d. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - e. Minimum Displacement Primary-Side Power Factor: 95 percent.
 - f. Overload Capability: 1.05 times the full-load current for 7 seconds.
 - g. Starting Torque: As required by fan and motor drive assembly.
 - h. Speed Regulation: 1 percent.
 - i. Speed Range: 10:1 speed range.
 - j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
 - k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
 - a. Overtemperature.
 - b. Short circuit at controller output.
 - c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
 - d. Open circuit at controller output.
 - e. Input undervoltage.
 - f. Input overvoltage.
 - g. Loss of input phase.
 - h. Reverse phase.
 - i. AC line switching transients.
 - j. Instantaneous overload, line to line or line to ground.
 - k. Sustained overload exceeding 100 percent of controller rated current.
 - l. Starting a rotating motor.
 - m. <Insert features>.
12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
13. Automatic Reset and Restart:
 - a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
 - b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
14. Visual Indication: On face of controller; indicating the following conditions:
 - a. Power on.
 - b. Run.
 - c. Overcurrent and overvoltage.
 - d. Motor speed (percent).
 - e. Various faults with alarm status.
 - f. Input kilovolt amperes.
 - g. Power factor.
 - h. Input kilowatts and kilowatt-hours.
 - i. Three-phase input and output voltage.
 - j. Three-phase input and output current.

- k. Output frequency.
 - l. Elapsed operating time (hours).
 - m. Diagnostic and service parameters.
 - n. **<Insert conditions>**.
15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
16. Control Signal Interface: A minimum of **[two]<Insert value>** analog inputs (0 to 10 V or 0/4 to 20 mA) and **[four]<Insert value>** programmable digital inputs.
17. Bypass Controller:
- a. Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.
 - b. Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller for safe servicing of variable-frequency controller.
 - c. Include "Bypass/VFC" manual selector switch on face of enclosure for local operator control of preferred controller.
 - d. Include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.
 - e. Install bypass controller in same enclosure as variable-frequency controller.

2.15 CONTROLS

A. Vibration Switch: For each fan drive.

- 1. Enclosure: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
- 2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
- 3. Switch shall have manual-reset button hardwired connection to fan motor electrical circuit.
- 4. Switch shall have field connection to a control system hardwired connection to fan motor electrical circuit.
- 5. Switch shall, on sensing excessive vibration, **[signal an alarm for connection to control system and]** shut down the fan.

B. Vibration Transmitter with Switch: For each fan drive.

- 1. Enclosure: NEMA 250, Type 4X.
- 2. Display: Local display of measured value, power, and alarm.
- 3. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point.
 - a. Cooling tower manufacturer shall select range that is suitable for cooling tower and recommend switch set point for proper operation and protection.
- 4. Transmitter: Continuous vibration level indication through a 4- to 20-mA signal for connection to control system.
- 5. Switch:
 - a. Relay and switch with manual-reset button for field connection to control system and hardwired connection to fan motor electrical circuit.
 - b. Switch shall, on sensing excessive vibration, signal an alarm to control system and shut down the fan.

6. Mounting: Locate out of cooling tower discharge airstream and mount in a location that is accessible[**and where display is easily viewable**].
 7. Field Electrical Connection Requirements: 120 V, single phase, 60 Hz.
- C. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch[**for connection to control system**].
1. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm[**through control system**].
- D. Control Package:
1. Factory installed and wired, and functionally tested at factory before shipment.
 2. NEMA 250, [Type 3R][Type 4][Type 4X] enclosure with removable internally mount backplate.
 3. Control-circuit transformer with primary and secondary side fuses.
 4. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
 5. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
 6. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
 7. Collection basin level controller complying with requirements in ["**Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve**"]["**Ultrasonic Collection Basin Water-Level Controller with Makeup-Water Valve**"] Paragraph in "Collection Basin Makeup-Water Assembly" Article.
 8. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Collection Basin Heater" Article.
 9. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
 10. Oil-level switch for each fan with a gear drive, complying with requirements in "Gear-Drive, Oil-Level Switch" Paragraph.
 11. Single-point, field-power connection to a [fused disconnect switch][nonfused disconnect switch][circuit breaker][**for each cooling tower cell**].
 - a. Branch power circuit to each motor and electric basin heater and to controls[**with a disconnect switch or circuit breaker**].
 - b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Include variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
 12. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
 13. Visual indication of status and alarm[**with momentary test push button**] for each motor.
 14. Audible alarm and silence switch.
 15. Visual indication of elapsed run time, graduated in hours for each motor.
 16. Cooling tower shall have hardware to enable control system to remotely monitor and display the following:
 - a. Operational status of each motor.
 - b. Cooling tower leaving-fluid temperature.
 - c. Fan vibration alarm.
 - d. Oil-level alarm.
 - e. Collection basin [high][low][high- and low]-water-level alarms.
 - f. <Insert conditions to be monitored>.

2.16 SERVICE ACCESS

- A. Doors:
 - 1. Large enough for personnel to access cooling tower internal components.
 - 2. Doors shall be hinged with handles operable from both sides of the door.
 - 3. Door materials shall match casing.
 - 4. Hinges and handles shall be **[corrosion resistant][stainless steel]<Insert material>**.
- B. External Ladders with Safety Cages: **[Aluminum][FRP][galvanized-steel][or][stainless-steel]<Insert material>** fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
- C. External Platforms with Handrails: **[Aluminum][FRP][galvanized-steel][or][stainless-steel]<Insert material>** bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
- D. External Motor Platforms with Handrails: **[Aluminum][FRP][galvanized-steel][or][stainless-steel]<Insert material>** bar grating.
- E. Fan Deck Floor between Cooling Tower Cells:
 - 1. Factory furnish reinforced fan deck floor panels between cooling tower cells for field installation.
 - 2. Floor materials shall match adjacent cooling tower cell fan deck.
 - 3. Fan deck floor shall fasten to and be supported by framing that is attached to cooling tower cells.
 - 4. Frame shall be constructed of same materials as cooling tower frame.
- F. Handrail: **[Aluminum][FRP][galvanized steel][or][stainless steel]<Insert material>** complete with kneerail and toeboard, around external platforms and top of cooling tower. Comply with 29 CFR 1910.23.
- G. Internal Platforms: **[Aluminum][FRP][galvanized-steel][or][stainless-steel]<Insert material>** bar grating.
 - 1. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between. Platform shall be elevated so that all parts are above the high water level of the collection basin.
 - 2. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach.
 - 3. **<Insert platform locations>**.
- H. Hardware: Galvanized steel when connecting galvanized-steel components; stainless steel when connecting other materials.

2.17 HOISTING ASSEMBLY

- A. Hoisting assembly consisting of pedestal base, davit arm, and winch to accommodate lowering and raising cooling tower components from their installed location to the base of cooling tower supports.
 - 1. Cooling tower components serviceable by hoisting assembly shall include, but not be limited to, fan stack, fan, fan drive, and fan motor.
 - 2. Hoisting assembly shall be designed to accommodate heaviest single component plus a safety factor of **[1.5]<Insert value>**.
 - 3. Construct cooling tower structural supports and reinforcing to accommodate lifting heaviest load

with safety factor.

B. Pedestal Base:

1. Equip each cooling tower cell with a pedestal base to accommodate an easily removable davit arm and winch assembly.
2. Position pedestal base at a location on cooling tower for hoisting assembly coverage to fan, fan motor, and fan drive assembly.
3. Pedestal base design shall be open-socket, or comparable, design that is configured to accept and secure an inserted portable davit arm.
4. Fit each pedestal base with an easily removable cap or plug designed to seal the open top of the base when the davit arm is not installed.
5. Fasten pedestal base to cooling tower using threaded hardware.
6. Construct pedestal base of **[hot-dip galvanized steel][or][300L series stainless steel]**.

C. Davit Arm:

1. Each cooling tower **[cell]** shall have a davit arm.
2. Davit arm shall be an adjustable telescoping design with angular adjustment to accommodate varying lifting conditions required by the application.
3. Davit arm assembly shall be portable and capable of being relocated to any cooling tower cell pedestal base.
4. Construct davit arm of **[hot-dip galvanized steel][or][300L series stainless steel]**.

D. Winch:

1. Each davit arm shall have **[an electric-][or][a hand-]**operated winch.
 - a. Electric winch shall include a power cord and plug for connection to a field-installed, weatherproof, 20-A receptacle with 120-V, single-phase, 60-Hz field power supply.
 - b. Hand-operated winch with gear mechanism to limit force on handle to not more than **80 lb (36 kg)** when lifting the heaviest component.
2. Coat winch body and exposed components with corrosion-resistant finish that is rated for outdoor duty in a highly corrosive environment and exposed to direct sunlight.
3. Winch cable shall be stainless steel and terminated with a stainless-steel hook and quick disconnecting mechanism. Cable length shall be at least 1.5 times actual length required for application.

E. Hardware: **[304][or][316]** series stainless steel.

F. Nameplate:

1. Stamped or engraved aluminum or stainless-steel nameplate with rated load capacity on each davit arm and pedestal.
2. Letter size legible from a distance **60 inches (1500 mm)** and not less than **1/2 inch (13 mm)**.
3. Fasten nameplate at multiple points with stainless-steel rivets or screws.

2.18 CAPACITIES AND CHARACTERISTICS

A. Number of Cells: **<Insert quantity>**.

B. Air-Inlet Arrangement: All sides.

C. Maximum Drift Loss: **[0.005]<Insert number>** percent of design water flow.

- D. Waterside:
1. Design Water Flow per Cell: **<Insert gpm (L/s)>**.
 2. Minimum Water Flow per Cell: **<Insert gpm (L/s)>**.
 3. Water Pressure Drop: **<Insert psig (kPa)>**.
 4. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 5. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
- E. Airside:
1. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 2. Altitude: **<Insert value>**.
 3. Airflow per Cell: **<Insert cfm (L/s)>**.
- F. Economizer-Mode Performance:
1. Water Flow per Cell: **<Insert gpm (L/s)>**.
 2. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 3. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
 4. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
- G. Fan Drive Assembly:
1. Type: **[Belt][direct][or][gear]**.
 2. Fan Motor:
 - a. Type: **[Single speed][Two speed, single winding][Two speed, two winding][Variable speed]**.
 - b. Motor Size per Cell: **<Insert number> hp**.
 - c. Full-Load Ampacity: **<Insert value>**.
 - d. Minimum Circuit Ampacity: **<Insert value>**.
 - e. Maximum Overcurrent Protection Device: **<Insert amperage>**.
 - f. Electrical Characteristics: **[208][240][480]<Insert value>-V ac, 3 phase, 60 Hz**.
- H. Sound Pressure Level: **<Insert dBA> at <Insert distance in feet (m)>[when measured according to CTI ATC 128]**.
- I. Collection Basin Heater:
1. Basin Water Temperature: **[40 deg F (5 deg C)]<Insert temperature>**.
 2. Outdoor Ambient Temperature: **[0 deg F (Minus 18 deg C)][Minus 20 deg F (Minus 29 deg C)]<Insert temperature>**.
 3. Capacity per Cell: **<Insert kilowatts>**.
 4. Full-Load Ampacity: **<Insert value>**.
 5. Minimum Circuit Ampacity: **<Insert value>**.
 6. Maximum Overcurrent Protection Device: **<Insert amperage>**.
 7. Electrical Characteristics: **[208][240][480]<Insert value>-V ac, 3 phase, 60 Hz**.
 8. Capacity per Cell: **<Insert MBtu/h (kW)>**.
 9. Coil Fluid Type: **[Water]<Insert fluid type>**.
 10. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
 11. Leaving-Fluid Temperature: **<Insert deg F (deg C)>**.
 12. Fluid Flow Rate: **<Insert gpm (L/s)>**.
 13. Fluid Pressure Drop: **<Insert psig (kPa)>**.
 14. Capacity per Cell: **<Insert MBtu/h (kW)>**.
 15. Steam Flow: **<Insert lb/h (L/s)>**.

16. Steam Pressure: <Insert psig (kPa)>.

2.19 SOURCE QUALITY CONTROL

- A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS, "Standard for the Certification of Water-Cooling Tower Thermal Performance."
1. Allow [Owner]<Insert entity> access to place where cooling towers are being tested. Notify Owner in writing at least [30]<Insert number> days in advance of testing.
 2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
- B. Seismic Performance Testing: Shake table tested by an independent[or a factory-certified] laboratory to certify performance complies with seismic requirements indicated.
1. Allow [Owner]<Insert entity> access to place where cooling towers are being tested. Notify Owner in writing at least [30]<Insert number> days in advance of testing.
 2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
- C. Factory Functional Tests:
1. Test collection and distribution basins after assembly, and prove free of leaks.
 2. Test factory-installed electric/electronic water-level controls for proper operation.
 3. Test factory-installed electric basin heaters for proper operation.
 4. Test factory-installed fan and drive assemblies for proper operation.
 5. Test factory-installed control package for proper operation.
 6. Test access doors to ensure smooth operation and proper fit.
 7. <Insert additional functional test requirements>.
 8. Allow [Owner]<Insert entity> access to place where cooling towers are being tested. Notify Owner in writing at least [30]<Insert number> days in advance of testing.
 9. Submit report documenting tests performed and results within one week of test date.
- D. Owner Travel Expenses:
1. Include cost associated with Owner travel expenses to witness testing. Total value attributed to travel expenses shall be clearly indicated.
 2. Expenses shall include round-trip coach airfare, out of town hotel accommodations, out of town meals (breakfast, lunch, and dinner), out of town ground transportation, and all associated taxes and fees.
 3. Exclude other incidental expenses not indicated.
 4. Include travel expenses for [one][two]<Insert value> Owner representative(s) with origin of <Insert city, state, and country>.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine cooling towers before installation. Reject cooling towers that are damaged.
- B. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting cooling tower performance, maintenance, and operation.

1. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.
2. Verify sizes and locations of concrete bases and support structure with actual equipment.
3. Verify sizes, locations, and anchoring attachments of structural-steel support structures.
4. Verify sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install cooling towers on support structure.

B. Equipment Mounting:

1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Maintain clearances required by governing code.

F. Loose Components: Install components, devices, and accessories furnished by manufacturer, with cooling tower, that are not factory mounted.

1. Loose components shall be installed by **[manufacturer's factory-trained service personnel][Contractor under supervision of manufacturer's factory-trained service personnel]**.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.

C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

D. Install drain piping with valve at cooling tower drain connections and at low points in piping.

E. Connect cooling tower overflows and drains, and piping drains, to sanitary sewage system.

F. Makeup-Water Piping:

1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow

meter, and drain connection with valve and union.

G. Supply and Return Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to entering cooling tower connections with shutoff valve, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to leaving cooling tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
4. Make connections to cooling tower with a flange.

H. Equalizer Piping:

1. Piping requirements to match supply and return piping.
2. Connect an equalizer pipe, full size of cooling tower connection, between tower cells.
3. Connect to cooling tower with shutoff valve and drain connection with valve.
4. Make connections to cooling tower with a flange.

I. Basin Heater Hot-Water Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve, strainer, control valve thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
4. Make connections with a flange, union, or mechanical coupling.

J. Basin Heater Steam and Condensate Piping:

1. Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
2. Connect steam supply connection with shutoff valve, strainer, control valve, pressure gage, and flow meter.
3. Connect to condensate connection with shutoff valve, strainer, and an appropriate steam trap assembly.
4. Make connections with a flange or union.

K. Basin Sweeper Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve, flow meter, and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve, flow meter, and drain connection with valve.
4. Make connections with a flange or union.

3.4 ELECTRICAL POWER CONNECTIONS

- A. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
- B. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.



- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
- D. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least **1/2 inch (13 mm)** high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.
- C. Connect control wiring between cooling tower control interface and control system for HVAC for remote monitoring and control of cooling towers. Comply with requirements in **[Section 230923 "Direct Digital Control (DDC) System for HVAC."]<Insert Section.>**
- D. Install label at each termination indicating control equipment designation serving cooling tower and the I/O point designation for each control connection. Comply with requirements in Section 260553 "Identification for Electrical Systems" for labeling and identifying products and installations.

3.6 FIELD TESTING PROVISIONS

- A. Include provisions for cooling tower future field-performance testing complying with **[ASME PTC 23][CTI ATC 105]**.
- B. Include provisions in field piping for future field-performance testing complying with **[ASME PTC 23][CTI ATC 105]**.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections **[with the assistance of a factory-authorized service representative]**.
- D. Tests and Inspections: Comply with **[ASME PTC 23][CTI ATC 105]**.
- E. Cooling towers will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.8 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
- B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.
- C. Obtain performance data from manufacturer.
 - 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Clean entire unit including basins.
 - b. Verify that accessories are properly installed.
 - c. Verify clearances for airflow and for cooling tower servicing.
 - d. Check for vibration isolation and structural support.
 - e. Lubricate bearings.
 - f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
 - g. Adjust belts to proper alignment and tension.
 - h. Verify proper oil level in gear-drive housing. Fill with oil to proper level.
 - i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
 - j. Check vibration switch setting. Verify operation.
 - k. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
 - l. Verify operation of basin heater and control.
 - m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
 - n. Replace defective and malfunctioning units.
- D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.
- E. Prepare a written startup report that records the results of tests and inspections.

3.9 ADJUSTING

- A. Set and balance water flow to each tower inlet.
- B. Adjust water-level control for proper operating level.
- C. Adjust basin heater control for proper operating set point.

3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain cooling towers.
 - 1. Video record the training sessions.
 - 2. Instructor shall be factory trained and certified.
 - 3. Perform not less than **[8]<Insert value>** hours of training.
 - 4. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
 - 5. Perform instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



-
6. Obtain Owner sign-off that training is complete.
 7. Owner training shall be held at Project site.

END OF SECTION 23 65 14 13

SECTION 23 65 14 14 - OPEN-CIRCUIT, INDUCED-DRAFT, CROSSFLOW COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes factory-assembled, open-circuit, induced-draft, crossflow cooling towers.

1.2 DEFINITIONS

- A. SCCR: Short-circuit current rating.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, pressure drop, fan performance data, rating at selected points indicated, and furnished specialties and accessories.
 - 2. Maximum flow rate.
 - 3. Minimum flow rate.
 - 4. Pressure required at cooling tower supply piping connections.
 - 5. Pressure required at basin heater supply piping connections.
 - 6. Pressure required at collection basin sweeper supply piping connections.
 - 7. Drift loss as percent of design flow rate.
 - 8. Volume of water in suspension for purposes of sizing remote storage.
 - 9. Sound:
 - a. Sound pressure levels for operation with fan off, fan at minimum speed, and design speed. If sound requirements are indicated at a specific distance, submit performance using same distance for comparative analysis.
 - b. Sound power levels in eight octave bands for operation with fans off, fans at minimum speed, and design speed.
 - 10. Performance curves for the following:
 - a. Varying entering-water temperatures from design to minimum in [one][five]<Insert number>-degree temperature increments.
 - b. Varying ambient wet-bulb temperatures from design to minimum in [one][five]<Insert number>-degree temperature increments.
 - c. Varying water flow rates from design to minimum in increments of [10]<Insert number> percent of flow rate difference between design and minimum flow rates.
 - d. Varying fan operation from design to minimum speed in [5][10]<Insert number> percent speed increments, and with fan off.
 - 11. Fan airflow at design conditions, brake horsepower, and drive losses (indicated in horsepower and percent of brake horsepower).
 - 12. Fan motor electrical characteristics including, but not limited to, speed, voltage, phase, hertz, amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
 - 13. Electrical power requirements for each cooling tower component requiring power.

B. Shop Drawings:

1. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
2. Assembled unit dimensions.
3. Diagram showing each separate piece requiring field assembly.
4. Shipped sub-assembly dimensions and weights for field assembly.
5. Assembled unit weight without water.
6. Operating weight and load distribution.
7. Unit vibration isolation[**and seismic controls**].
8. Required clearances for maintenance and operation.
9. Sizes and dimensioned locations of piping and wiring connections.
10. Diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Design Calculations: Calculate requirements for selecting vibration isolators [**and seismic restraints**][**and wind restraints**] and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Drawings on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Structural supports.
 - b. Piping roughing-in requirements.
 - c. Conduit and wiring roughing-in requirements for controls and electrical power, including spaces reserved for controls and electrical equipment.
 - d. Access requirements, including working clearances for controls and electrical equipment, and service clearances. Mark and label clearances on drawings.
2. Drawings showing plans, sections, and elevation views, drawn to scale of at least **<Insert scale>**.
3. Each view to show screened background with the following:
 - a. Structural grids.
 - b. Adjacent walls, floors, and roofs.
 - c. Equipment and products of other trades that are located in vicinity of cooling towers and are part of final installation, such as, controls, power, lighting, fire-suppression systems, and plumbing systems.

B. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their

installation requirements.

- C. Product Certificates: For certification required in "Quality Assurance" Article.
- D. Field Test Reports: Include startup service reports.
- E. Source quality-control reports.
- F. Field quality-control reports.
- G. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.
- B. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Belts:
 - 1. Furnish **[one]**<Insert number> set(s) of matching belts for each unique belt configuration and size furnished.
- B. Tool Kit:
 - 1. A tool kit specially designed by cooling tower manufacturer for use in servicing cooling tower(s) furnished.
 - 2. Special tools required to service components not readily available to Owner service personnel in performing routine maintenance.
 - 3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Cooling Tower Tool Kit." Text size shall be at least **1 inch (25 mm)** high.
 - 4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least **1/2 inch (13 mm)** high.
- C. Touchup Coating: **[32-oz. (1-L)]**<Insert volume> container of paint coating used. Label outside of container with detailed description of coating to allow for procurement of a matching coating in the future.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: **[Certified by CTI][An NRTL]**.
- B. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.
- C. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."



1.8 DELIVERY, STORAGE, AND HANDLING

- A. Coordinate requirements for multi-piece assembly for shipment. Limit the number of separate pieces for field installation to as few as possible.
- B. If factory assembly of multiple pieces is required for testing or other reasons, disassemble cooling tower into major assemblies as required by installation before packaging for shipment.
 - 1. Clearly label each separate package with a unique designation and include assembly instructions for complete cooling tower.
- C. Install seals on gear-drive assemblies to eliminate oil leakage during shipment if shipped with oil.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:
 - 1. All components of cooling tower.
 - 2. Fan assembly including fan, drive, and motor.
 - 3. **<Insert components requiring extended warranty>.**
 - 4. Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OPEN-CIRCUIT, INDUCED-DRAFT, CROSSFLOW COOLING TOWERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Amcot Cooling Tower Corp.]**
 - 2. **[Baltimore Aircoil Company]**
 - 3. **[EVAPCO, Inc]**
 - 4. **[Marley; a brand of SPX Cooling Technologies, Inc.]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Amcot Cooling Tower Corp.]**
 - 2. **[Baltimore Aircoil Company]**
 - 3. **[EVAPCO, Inc]**
 - 4. **[Marley; a brand of SPX Cooling Technologies, Inc.]**
 - 5. **<Insert manufacturer's name>**

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cooling tower support structure **[and seismic restraints][and wind**

restraints], including comprehensive engineering analysis.

- B. Structural Performance: Cooling tower and support structure shall withstand the effects of loads and stresses within limits and under conditions indicated according to **[ASCE/SEI 7][the IBC][governing codes]<Insert requirement>**.
- C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **and the unit will be fully operational after the seismic event**."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. Component Amplification Factor: **<Insert value>**.
 - 4. Component Response Modification Factor: **<Insert value>**.
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Operation Following Loss of Normal Power:
 - 1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
 - 2. Include means and methods required to satisfy requirement even if not explicitly indicated.
- G. Vibration:
 - 1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry-standard requirements for cooling towers.
 - 2. Critical speed shall be at least 115 percent of design speed.

2.3 DESIGN ARRANGEMENT

- A. Crossflow design with airflow from two sides and induced-draft, top-mounted axial fan and gravity distribution basin.
- B. Crossflow design with airflow from one side and induced-draft, top-mounted axial fan and gravity distribution basin.
- C. Crossflow design with airflow from one side and induced-draft, side-mounted axial fan and gravity distribution basin.

2.4 CASING AND FRAME

- A. Casing Material: **[FRP with UV inhibitors][Galvanized steel, ASTM A653/A653M, G235 (Z700) coating][Polymer-coated galvanized steel][Stainless steel, Grade 304][Stainless steel, Grade 316]<Insert material>**.

- B. Frame Material: **[FRP with UV inhibitors][galvanized steel, ASTM A653/A653M, G235 (Z700) coating][polymer-coated galvanized steel][stainless steel, Grade 304][stainless steel, Grade 316][or][materials to match casing]<Insert material>**.
- C. Hardware: **[Galvanized][or][stainless]** steel.
- D. Joints and Seams: Sealed watertight.
- E. Welded Connections: Sealed watertight **[by continuous welds]**.

2.5 COLLECTION BASIN

- A. Field-Constructed Collection Basin: Configure tower without a factory-assembled collection basin for installation and operation with a field-constructed collection basin.
- B. Factory-Assembled Collection Basin:
 - 1. Material: **[FRP with UV inhibitors][Galvanized steel, ASTM A653/A653M, G235 (Z700) coating][Polymer-coated galvanized steel][Stainless steel, Grade 304][Stainless steel, Grade 316]<Insert material>**.
 - 2. Hardware: **[Galvanized][or][stainless]** steel.
 - 3. Joints and Seams: Sealed watertight.
 - 4. Welded Connections: Sealed watertight **[by continuous welds]**.
 - 5. Removable **[stainless-steel]** strainer with openings smaller than nozzle orifices.
 - 6. Overflow and drain connections.
 - 7. Makeup-water connection.
 - 8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.
 - 9. Removable equalization flume plate between adjacent cells of multiple-cell towers.
 - 10. Equalizer connection for field-installed equalizer piping configured to mate to ASME B16.5, Class 150 flange.
 - 11. Basin Sweeper Distribution Piping and Nozzles:
 - a. Pipe Material: **[PVC][or][CPVC]<Insert material>**, Schedule 40 or heavier, treated with UV inhibitors and intended for continuous exposure to direct sunlight with degradation.
 - b. Nozzle Material: **[Plastic]<Insert material>**.
 - c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.
 - d. Basin penetrations sealed watertight.
 - e. Field Connections: Threaded or flanged depending on pipe size. Thread for sizes through **<Insert pipe size>** and flanged for larger sizes.

2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

- A. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
- B. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:
 - 1. Enclosures: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
 - 2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to **[control makeup-water valve][control makeup-water valve and low-level alarm][control makeup-water valve and low- and high-level alarms][control makeup-water valve, low- and high-level alarms, and output for shutoff of pump on low level]**.
 - 3. Electrode Probes: Stainless steel.

4. Water Stilling Chamber: **[Corrosion-resistant material][FRP][Galvanized steel][PVC pipe][Stainless steel, Grade 304][Stainless steel, Grade 316]<Insert material>**.
5. Makeup-Water Valve:
 - a. Slow closing **[with stainless-steel body]**.
 - b. Actuator controlled and powered through level controller in response to water-level set point.
 - c. Actuator Enclosure: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
 - d. Fail Position: **[Closed][Open][Last]**.
 - e. Action: **[Two position][or][modulating]**.
6. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

C. Ultrasonic Collection Basin Water-Level Controller with Makeup-Water Valve:

1. Enclosure: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
2. Controller:
 - a. Ultrasonic level sensor/transmitter with local display of measured value.
 - b. Factory wired to terminal strip.
 - c. Control make-up water valve in response to water-level set point.
 - d. Adjustable level, alarm signal through relay closure **[for connection to control system]**.
 - e. Signal continuous level indication through a 4- to 20-mA signal **[for connection to control system]**.
3. Water Stilling Chamber: **[Corrosion-resistant material][FRP][Galvanized steel][PVC pipe][Stainless steel]<Insert material>**.
4. Makeup-Water Valve:
 - a. Slow closing **[with stainless-steel body]**.
 - b. Valve actuator controlled and powered through level controller in response to water-level set point.
 - c. Actuator Enclosure: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
 - d. Fail Position: **[Closed][Open][Last]**.
 - e. Action: **[Two position][or][modulating]**.
5. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.7 COLLECTION BASIN HEATER

A. Electric Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, **[Type 3R][Type 4][Type 4X]<Insert Type>**.
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a **[fused disconnect switch][nonfused disconnect switch][circuit breaker]** and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except connections to each electric basin heater shall be liquidtight conduit.

a. Raceway shall be corrosion-resistant [**stainless steel**][or][**PVC coated steel**].

- B. Hot-Water-Coil Heater: Manufacturer's standard heater with indicated capacity.
- C. Steam-Coil Heater: Manufacturer's standard heater with indicated capacity.
- D. Steam-Injector Heater: Manufacturer's standard offering heater with indicated capacity.

2.8 GRAVITY WATER DISTRIBUTION BASIN

- A. Design: Non-pressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.
- 1. Material: [**FRP with UV inhibitors**][**galvanized steel, ASTM A653/A653M, G235 (Z700) coating**][**polymer-coated galvanized steel**][or][**stainless steel**]**<Insert material>**.
 - 2. Location: Over each bank of fill with easily replaceable [**plastic**]**<Insert material>** spray nozzles mounted in bottom of basin.
 - 3. Inlet Connection: Configured to mate to ASME B16.5, Class 150 flange.
 - 4. Fasteners: [**Galvanized**][or][**stainless**] steel.
 - 5. Joints and Seams: Sealed watertight.
 - 6. Welded Connections: Sealed watertight[**by continuous welds**].
 - 7. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing and achieve proper operation while operating throughout the flow range indicated.
 - a. Manufacturer has option to use individual nozzle cups in lieu of partitioning dams to achieve operation within flow range (design to minimum) indicated.
 - 8. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable [**corrosion-resistant**][**stainless-steel**] hardware. Panels reinforced to accommodate service personnel walking on the panels without resulting in permanent deflection and damage.
 - 9. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity distribution basin.
 - 10. Single-Inlet, Field Pipe Connection: [**Galvanized-steel**][**PVC**] pipe arranged to achieve balancing of flow within cooling tower cell without the need for additional balancing valves. Pipe each cooling tower cell internally to a single, field connection suitable for mating to ASME B16.5, Class 150 flange and located on the [**bottom**][**side**] unless otherwise indicated.

2.9 FILL

- A. Materials: PVC, with maximum flame-spread index of [**5**][**25**]**<Insert value>** according to ASTM E84.
- B. Minimum Thickness: [**15 mils (0.4 mm)**][**20 mils (0.5 mm)**]**<Insert value>**, before forming.
- C. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
- D. Fill Material Operating Temperature: Suitable for entering-water temperatures up through [**120 deg F (49 deg C)**]**<Insert temperature>**.
- E. Hardware: [**Galvanized**][or][**stainless**] steel.

2.10 DRIFT ELIMINATORS

- A. Material: **[FRP][PVC][FRP or PVC]<Insert material>**; with maximum flame-spread index of **[5][25]<Insert value>** according to ASTM E84.
- B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
- C. Configuration: Multipass, designed and tested to reduce water carryover to **[0.005]<Insert number>** percent of design flow rate indicated.
- D. Location: **[Integral to][Separate and removable from]** fill.
- E. Hardware: **[Galvanized][or][stainless]** steel.

2.11 AIR INLET

- A. Air-Intake Louvers:
 - 1. Material: **[FRP][PVC][Matching casing]<Insert material>**.
 - 2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
 - 3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
 - 4. Location: **[Integral to][Separate from]** fill.
- B. **[Removable]**Air-Intake Screens:
 - 1. **[Galvanized][Polymer-coated, galvanized][Stainless]**-steel wire mesh with openings of size sufficient to not restrict airflow or impact performance.
 - 2. Segmented into manageable individual sections arranged to facilitate independent removal of each section without disturbing adjoining sections.
- C. Hardware: **[Galvanized][or][stainless]** steel.

2.12 FAN AND DRIVE ASSEMBLY

- A. Axial Fan: Balanced at the factory[**after assembly**].
 - 1. Blade Material: **[Aluminum][FRP][or][galvanized steel]<Insert material>**.
 - 2. Hub Material: **[Aluminum][FRP][or][galvanized steel]<Insert material>**.
 - 3. Blade Pitch: Field adjustable.
 - 4. Fan Shaft: **[Corrosion resistant][Stainless steel]<Insert material>**.
 - 5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**. Bearings designed for an L-10 life of **[40,000][50,000][100,000]<Insert value>** hours.
 - 6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
- B. Belt Drive:
 - 1. Service Factor: **[1.5]<Insert value>** based on motor nameplate horsepower.
 - 2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.



3. Belt:
 - a. Multiple V-belt design with a matched set of **[cogged]** belts.
 - b. One-piece, multigrooved, solid-back belt.
4. Belt Material: Oil resistant, non-static conducting, and constructed of neoprene polyester cord.
5. Belt-Drive Guard: Comply with OSHA regulations.
6. Two-Motor, Single-Fan Drive:
 - a. Two single-speed motors per fan, one sized for full speed and load and the other sized for **[67]<Insert number>** percent of full-load speed.
 - b. Each motor shall have belt drive and be configured for operation when other motor fails.
 - c. Controls and wiring same as two-speed, two-winding motor.
- C. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.
- D. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.
 1. Gear Drive and Coupling Service Factor: **[2.0]<Insert value>** based on motor nameplate horsepower.
 2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
 3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
 4. Operation: Able to operate both forward and in reverse. Able to operate throughout entire speed range from design speed indicated down to **[10][20]<Insert value>** of design speed.
 5. Drive-to-Motor Connection: **[Close coupled to motor using a flexible coupling.][Connected to motor located outside of cooling tower casing by a full-floating drive shaft.]**
 6. Drive Shaft Material: **[Corrosion resistant][Stainless steel]**, and fitted with flexible couplings on both ends.
 7. Drive Guards: Exposed shaft and couplings shall have guards according to OSHA regulations.
 8. Extend oil fill, drain, and vent to outside of cooling tower casing using **[galvanized-steel][or][stainless-steel]** piping. Include oil-level sight glass.
- E. Fan Motor:
 1. Comply with NEMA MG 1 unless otherwise indicated.
 2. Description: NEMA MG 1, **[Design B]<Insert design>**, as required to comply with capacity and torque characteristics; medium induction motor.
 3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
 4. Motor Enclosure: **[Totally enclosed][Totally enclosed air-over (TEAO)][Totally enclosed fan-cooled (TEFC)][and with epoxy or polyurethane finish].**
 5. Rotor: Random-wound, squirrel cage.
 6. Energy Efficiency: **[Comply with ASHRAE/IES 90.1][NEMA Premium Efficient].**
 7. Service Factor: **[1.15]<Insert value>**.
 8. Temperature Rise: **[Match][One class lower than]<Insert requirements>** insulation rating.
 9. Insulation: **[Class F][Class H]<Insert class>**.
 10. Variable-Speed Motors: Inverter-duty rated per NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
 11. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
 12. Severe-Duty Rating:

- a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
 - b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C.).
 - c. Internal Heater: Automatically energized when motor is de-energized.
 - d. Complying with IEEE 841.
13. Motor Base: Adjustable, or other suitable provision[**for adjusting belt tension**].
 14. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than **[0.5]<Insert number>** percent of motor nameplate horsepower.

F. Hardware: [**Galvanized**][or][**stainless**] steel.

2.13 AIR DISCHARGE

A. Low-Profile Fan Discharge Stack:

1. Manufacturer's standard low-profile design.
2. Material: [**Material to match casing**][FRP][**Galvanized steel**][**Polymer-coated, galvanized steel**][**Stainless steel**]**<Insert material>**.
3. Stack Extension: Fabricated to extend above fan deck **<Insert distance>** unless otherwise indicated.
4. Stack Termination: Wire-mesh, [**galvanized-steel**][**polymer-coated, galvanized-steel**][or][**stainless-steel**]**<Insert material>** screens; segmented into multiple removable pie sections and complying with OSHA regulations.

B. Velocity Recovery Fan Discharge Stack:

1. Design: Tapered and expanded for velocity recovery and improved energy efficiency.
2. Material: FRP or material matching casing.
3. Stack Height: Fabricated to extend above fan deck at least **[5 feet (1.5 m)]<Insert dimension>** unless otherwise indicated.
4. Service Access: Fabricated of multiple segments to facilitate removal of fan and drive components from overhead.
5. Stack Termination: Wire-mesh, [**galvanized-steel**][**polymer-coated, galvanized-steel**][or][**stainless-steel**]**<Insert material>** screens; segmented into multiple removable pie sections and complying with OSHA regulations.

C. Hardware: [**Galvanized**][or][**stainless**] steel.

2.14 ELECTRICAL POWER

A. Factory Furnish for Field Installation: A [**disconnect switch**][**motor controller**][**variable-frequency controller**] for each fan motor.

B. Factory Install: A [**disconnect switch**][**motor controller**][**variable-frequency controller**] for each fan motor.

1. Locate in a convenient and field-accessible location within sight of motor.
2. Installation shall comply with NFPA 70.
3. Wire, Conduit, and Enclosures:

- a. Minimum Conduit Size: **[0.75 inch (20 mm)]<Insert size>**.
- b. Materials: Corrosion resistant **[and constructed of stainless steel or PVC coated steel]**.
- c. Motor Termination: Liquidtight conduit, not to exceed **36 inches (900 mm)** long.
- d. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware **[constructed of stainless steel]**.
- e. Wire:
 - 1) Copper, rated for 600-V, solid wire for size **[No. 10 AWG]<Insert wire size>** and smaller and stranded wire for larger sizes.
 - 2) Minimum Wire Size: **[No. 12 AWG]<Insert wire size>**.
 - 3) Each circuit shall have a ground wire.
 - 4) Install wire in conduit.
- f. Boxes, Condulets, and Enclosures: NEMA 250, **[Type 3R][Type 4][Type 4X]**.

C. Disconnect Switches:

1. Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.
2. Three pole, **[fused][or][nonfused]**.
3. 600 V rated.
4. Minimum SCCR: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert value> A**.
5. Enclosure: NEMA 250, **[Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]<Insert Type>**.
6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
9. Include a solid neutral as required by authorities having jurisdiction.
10. Disconnect switch shall have a ground lug for ground wire termination.
11. Operating handle shall be lockable in open position.
12. Horsepower rated.
13. Feed through or double lugged.

D. Motor Controllers:

1. NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.
2. Configured for control of single- or multispeed motors as indicated.
3. Enclosure: NEMA 250, **[Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]<Insert Type>**, with hinged full-front access door with lock and key.
4. Externally Operated[, **Door-Interlocked**] Disconnect: **[Fused disconnect switch][Nonfused disconnect switch][Circuit breaker]** with lockable handle.
5. SCCR: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert value> A**.
6. Hand-Off-Auto Switch: Mounted on face of enclosure.
7. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
8. Control Relays: Time-delay relays.
9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
10. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
11. Number-of-Starts Counter: Numerical readout on face of enclosure.

E. Variable-Frequency Controllers:

1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
2. Enclosure: Unit mounted, NEMA 250, [Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]<Insert Type>, with hinged full-front access door with lock and key.
3. Externally Operated[, Door-Interlocked] Disconnect: [Fused disconnect switch][Nonfused disconnect switch][Circuit breaker] with lockable handle.
4. Minimum SCCR: As required by electrical power distribution system, but not less than [42,000][65,000]<Insert value> A.
5. Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
9. Operating Requirements:
 - a. Input AC Voltage Tolerance: [10]<Insert number> percent.
 - b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - c. Capable of driving full motor load, without derating.
 - d. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - e. Minimum Displacement Primary-Side Power Factor: 95 percent.
 - f. Overload Capability: 1.05 times the full-load current for 7 seconds.
 - g. Starting Torque: As required by fan and motor drive assembly.
 - h. Speed Regulation: 1 percent.
 - i. Speed Range: 10:1 speed range.
 - j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
 - k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
 - a. Overtemperature.
 - b. Short circuit at controller output.
 - c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
 - d. Open circuit at controller output.
 - e. Input undervoltage.
 - f. Input overvoltage.
 - g. Loss of input phase.
 - h. Reverse phase.
 - i. AC line switching transients.
 - j. Instantaneous overload, line to line or line to ground.
 - k. Sustained overload exceeding 100 percent of controller rated current.
 - l. Starting a rotating motor.
 - m. <Insert features>.
12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
13. Automatic Reset and Restart:
 - a. Capable of multiple restarts after controller fault or on return of power after an interruption

- and before shutting down for manual reset or fault correction.
 - b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
14. Visual Indication: On face of controller; indicating the following conditions:
- a. Power on.
 - b. Run.
 - c. Overcurrent and overvoltage.
 - d. Motor speed (percent).
 - e. Various faults with alarm status.
 - f. Input kilovolt amperes.
 - g. Power factor.
 - h. Input kilowatts and kilowatt-hours.
 - i. Three-phase input and output voltage.
 - j. Three-phase input and output current.
 - k. Output frequency.
 - l. Elapsed operating time (hours).
 - m. Diagnostic and service parameters.
 - n. **<Insert conditions>**.
15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
16. Control Signal Interface: A minimum of **[two]<Insert value>** analog inputs (0 to 10 V or 0/4 to 20 mA) and **[four]<Insert value>** programmable digital inputs.
17. Bypass Controller:
- a. Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.
 - b. Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller for safe servicing of variable-frequency controller.
 - c. Include "Bypass/VFC" manual selector switch on face of enclosure for local operator control of preferred controller.
 - d. Include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.
 - e. Install bypass controller in same enclosure as variable-frequency controller.

2.15 CONTROLS

A. Vibration Switch: For each fan drive.

- 1. Enclosure: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
- 2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
- 3. Switch shall have manual-reset button hardwired connection to fan motor electrical circuit.
- 4. Switch shall have field connection to a control system hardwired connection to fan motor electrical circuit.
- 5. Switch shall, on sensing excessive vibration, **[signal an alarm for connection to control system and]** shut down the fan.

B. Vibration Transmitter with Switch: For each fan drive.

- 1. Enclosure: NEMA 250, Type 4X.

2. Display: Local display of measured value, power, and alarm.
 3. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point.
 - a. Cooling tower manufacturer shall select range that is suitable for cooling tower and recommend switch set point for proper operation and protection.
 4. Transmitter: Continuous vibration level indication through a 4- to 20-mA signal for connection to control system.
 5. Switch:
 - a. Relay and switch with manual-reset button for field connection to control system and hardwired connection to fan motor electrical circuit.
 - b. Switch shall, on sensing excessive vibration, signal an alarm to control system and shut down the fan.
 6. Mounting: Locate out of cooling tower discharge airstream and mount in a location that is accessible **[and where display is easily viewable]**.
 7. Field Electrical Connection Requirements: 120 V, single phase, 60 Hz.
- C. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch **[for connection to control system]**.
1. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm **[through control system]**.
- D. Control Package:
1. Factory installed and wired, and functionally tested at factory before shipment.
 2. NEMA 250, **[Type 3R][Type 4][Type 4X]** enclosure with removable internally mount backplate.
 3. Control-circuit transformer with primary and secondary side fuses.
 4. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
 5. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
 6. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
 7. Collection basin level controller complying with requirements in **["Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve"] ["Ultrasonic Collection Basin Water-Level Controller with Makeup-Water Valve"]** Paragraph in "Collection Basin Makeup-Water Assembly" Article.
 8. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Collection Basin Heater" Article.
 9. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
 10. Oil-level switch for each fan with a gear drive, complying with requirements in "Gear-Drive, Oil-Level Switch" Paragraph.
 11. Single-point, field-power connection to a **[fused disconnect switch] [nonfused disconnect switch] [circuit breaker] [for each cooling tower cell]**.
 - a. Branch power circuit to each motor and electric basin heater and to controls **[with a disconnect switch or circuit breaker]**.
 - b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Include variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
 12. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.

13. Visual indication of status and alarm[**with momentary test push button**] for each motor.
14. Audible alarm and silence switch.
15. Visual indication of elapsed run time, graduated in hours for each motor.
16. Cooling tower shall have hardware to enable control system to remotely monitor and display the following:
 - a. Operational status of each motor.
 - b. Cooling tower leaving-fluid temperature.
 - c. Fan vibration alarm.
 - d. Oil-level alarm.
 - e. Collection basin **[high][low][high- and low]**-water-level alarms.
 - f. **<Insert conditions to be monitored>**.

2.16 SERVICE ACCESS

A. Doors:

1. Large enough for personnel to access cooling tower internal components from both cooling tower end walls.
2. Doors shall be hinged with handles operable from both sides of the door.
3. Door materials shall match casing.
4. Hinges and handles shall be **[corrosion resistant][stainless steel]<Insert material>**.

B. External Ladders with Safety Cages: **[Aluminum][FRP][galvanized-steel][or][stainless-steel]<Insert material>** fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.

C. External Platforms with Handrails: **[Aluminum][FRP][galvanized-steel][or][stainless-steel]<Insert material>** bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.

D. External Motor Platforms with Handrails: **[Aluminum][FRP][galvanized-steel][or][stainless-steel]<Insert material>** bar grating.

E. Fan Deck Floor between Cooling Tower Cells:

1. Factory furnish reinforced fan deck floor panels between cooling tower cells for field installation.
2. Floor materials shall match adjacent cooling tower cell fan deck.
3. Fan deck floor shall fasten to and be supported by framing that is attached to cooling tower cells.
4. Frame shall be constructed of same materials as cooling tower frame.

F. Handrail: **[Aluminum][FRP][galvanized steel][or][stainless steel]<Insert material>** complete with kneerail and toeboard, around external platforms and top of cooling tower. Comply with 29 CFR 1910.23.

G. Internal Platforms: **[Aluminum][FRP][galvanized-steel][or][stainless-steel]<Insert material>** bar grating.

1. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
2. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.
3. **<Insert platform locations>**.

- H. Hardware: Galvanized steel when connecting galvanized-steel components; stainless steel when connecting other materials.

2.17 HOISTING ASSEMBLY

- A. Hoisting assembly consisting of pedestal base, davit arm, and winch to accommodate lowering and raising cooling tower components from their installed location to the base of cooling tower supports.
1. Cooling tower components serviceable by hoisting assembly shall include, but not be limited to, fan stack, fan, fan drive, and fan motor.
 2. Hoisting assembly shall be designed to accommodate heaviest single component plus a safety factor of **[1.5]<Insert value>**.
 3. Construct cooling tower structural supports and reinforcing to accommodate lifting heaviest load with safety factor.
- B. Pedestal Base:
1. Equip each cooling tower cell with a pedestal base to accommodate an easily removable davit arm and winch assembly.
 2. Position pedestal base at a location on cooling tower fan (top) deck for hoisting assembly coverage to fan, fan motor, and fan drive assembly.
 3. Pedestal base design shall be open-socket, or comparable, design that is configured to accept and secure an inserted portable davit arm.
 4. Fit each pedestal base with an easily removable cap or plug designed to seal the open top of the base when the davit arm is not installed.
 5. Fasten pedestal base to cooling tower using threaded hardware.
 6. Construct pedestal base of **[hot-dip galvanized steel][or][300L series stainless steel]**.
- C. Davit Arm:
1. Each cooling tower **[cell]** shall have a davit arm.
 2. Davit arm shall be an adjustable telescoping design with angular adjustment to accommodate varying lifting conditions required by the application.
 3. Davit arm assembly shall be portable and capable of being relocated to any cooling tower cell pedestal base.
 4. Construct davit arm of **[hot-dip galvanized steel][or][300L series stainless steel]**.
- D. Winch:
1. Each davit arm shall have **[an electric-][or][a hand-]**operated winch.
 - a. Electric winch shall include a power cord and plug for connection to a field-installed, weatherproof, 20-A receptacle with 120-V, single-phase, 60-Hz field power supply.
 - b. Hand-operated winch with gear mechanism to limit force on handle to not more than **80 lb (36 kg)** when lifting the heaviest component.
 2. Coat winch body and exposed components with corrosion-resistant finish that is rated for outdoor duty in a highly corrosive environment and exposed to direct sunlight.
 3. Winch cable shall be stainless steel and terminated with a stainless-steel hook and quick disconnecting mechanism. Cable length shall be at least 1.5 times actual length required for application.
- E. Hardware: **[304][or][316]** series stainless steel.
- F. Nameplate:



1. Stamped or engraved aluminum or stainless-steel nameplate with rated load capacity on each davit arm and pedestal.
2. Letter size legible from a distance of **60 inches (1500 mm)** and not less than **1/2 inch (13 mm)**.
3. Fasten nameplate at multiple points with stainless-steel rivets or screws.

2.18 CAPACITIES AND CHARACTERISTICS

- A. Number of Cells: **<Insert quantity>**.
- B. Air-Inlet Arrangement: **[Single side][Two sides]**.
- C. Maximum Drift Loss: **[0.005]<Insert number>** percent of design water flow.
- D. Waterside:
 1. Design Water Flow per Cell: **<Insert gpm (L/s)>**.
 2. Minimum Water Flow per Cell: **<Insert gpm (L/s)>**.
 3. Water Pressure Drop: **<Insert psig (kPa)>**.
 4. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 5. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
- E. Airside:
 1. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 2. Altitude: **<Insert value>**.
 3. Airflow per Cell: **<Insert cfm (L/s)>**.
- F. Economizer-Mode Performance:
 1. Water Flow per Cell: **<Insert gpm (L/s)>**.
 2. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 3. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
 4. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
- G. Fan Drive Assembly:
 1. Type: **[Belt][direct][or][gear]**.
 2. Fan Motor:
 - a. Type: **[Single speed][Two speed, single winding][Two speed, two winding][Variable speed]**.
 - b. Motor Size per Cell: **<Insert number>** hp.
 - c. Full-Load Ampacity: **<Insert value>**.
 - d. Minimum Circuit Ampacity: **<Insert value>**.
 - e. Maximum Overcurrent Protection Device: **<Insert amperage>**.
 - f. Electrical Characteristics: **[208][240][480]<Insert value>-V ac, 3 phase, 60 Hz.**
- H. Sound Pressure Level: **<Insert dBA>** at **<Insert distance in feet (m)>** **[when measured according to CTI ATC 128]**.
- I. Collection Basin Heater:
 1. Basin Water Temperature: **[40 deg F (5 deg C)]<Insert temperature>**.

2. Outdoor Ambient Temperature: [0 deg F (Minus 18 deg C)][Minus 20 deg F (Minus 29 deg C)]<Insert temperature>.
3. Capacity per Cell: <Insert kilowatts>.
4. Full-Load Ampacity: <Insert value>.
5. Minimum Circuit Ampacity: <Insert value>.
6. Maximum Overcurrent Protection Device: <Insert amperage>.
7. Electrical Characteristics: [208][240][480]<Insert value>-V ac, 3 phase, 60 Hz.
8. Capacity/Cell: <Insert MBtu/h (kW)>.
9. Coil Fluid Type: [Water]<Insert fluid type>.
10. Entering-Fluid Temperature: <Insert deg F (deg C)>.
11. Leaving-Fluid Temperature: <Insert deg F (deg C)>.
12. Fluid Flow Rate: <Insert gpm (L/s)>.
13. Fluid Pressure Drop: <Insert psig (kPa)>.
14. Capacity/Cell: <Insert MBtu/h (kW)>.
15. Steam Flow: <Insert lb/h (L/s)>.
16. Steam Pressure: <Insert psig (kPa)>.

2.19 SOURCE QUALITY CONTROL

- A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS, "Standard for the Certification of Water-Cooling Tower Thermal Performance."
 1. Allow [Owner]<Insert entity> access to place where cooling towers are being tested. Notify Owner in writing at least [30]<Insert number> days in advance of testing.
 2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
- B. Seismic Performance Testing: Shake table tested by an independent [or a factory-certified]laboratory to certify performance complies with seismic requirements indicated.
 1. Allow [Owner]<Insert entity> access to place where cooling towers are being tested. Notify Owner in writing at least [30]<Insert number> days in advance of testing.
 2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
- C. Factory Functional Tests:
 1. Test collection and distribution basins after assembly, and prove free of leaks.
 2. Test factory-installed electric/electronic water-level controls for proper operation.
 3. Test factory-installed electric basin heaters for proper operation.
 4. Test factory-installed fan and drive assemblies for proper operation.
 5. Test factory-installed control package for proper operation.
 6. Test access doors to ensure smooth operation and proper fit.
 7. <Insert additional functional test requirements>.
 8. Allow [Owner]<Insert entity> access to place where cooling towers are being tested. Notify Owner in writing at least [30]<Insert number> days in advance of testing.
 9. Submit report documenting tests performed and results within one week of test date.
- D. Owner Travel Expenses:
 1. Include cost associated with Owner travel expenses to witness testing. Total value attributed to travel expenses shall be clearly indicated.
 2. Expenses shall include round-trip coach airfare, out of town hotel accommodations, out of town meals (breakfast, lunch, and dinner), out of town ground transportation, and all associated taxes and fees.



3. Exclude other incidental expenses not indicated.
4. Include travel expenses for [one][two]<Insert value> Owner representative(s) with origin of <Insert city, state, and country>.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine cooling towers before installation. Reject cooling towers that are damaged.
- B. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting cooling tower performance, maintenance, and operation.
 1. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.
 2. Verify sizes and locations of concrete bases and support structure with actual equipment.
 3. Verify sizes, locations, and anchoring attachments of structural-steel support structures.
 4. Verify sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install cooling towers on support structure.
- B. Equipment Mounting:
 1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Maintain manufacturer's recommended clearances for service and maintenance.
- E. Maintain clearances required by governing code.
- F. Loose Components: Install components, devices and accessories furnished by manufacturer, with cooling tower, that are not factory mounted.
 1. Loose components shall be installed by **[manufacturer's factory-trained service personnel][Contractor under supervision of manufacturer's factory-trained service personnel]**.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.
- C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.
- D. Install drain piping with valve at cooling tower drain connections and at low points in piping.
- E. Connect cooling tower overflows and drains, and piping drains, to sanitary sewage system.
- F. Makeup-Water Piping:
 - 1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
 - 2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow meter, and drain connection with valve and union.
- G. Supply and Return Piping:
 - 1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 2. Connect to entering cooling tower connections with shutoff valve, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
 - 3. Connect to leaving cooling tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
 - 4. Make connections to cooling tower with a flange.
- H. Equalizer Piping:
 - 1. Piping requirements to match supply and return piping.
 - 2. Connect an equalizer pipe, full size of cooling tower connection, between tower cells.
 - 3. Connect to cooling tower with shutoff valve and drain connection with valve.
 - 4. Make connections to cooling tower with a flange.
- I. Basin Heater Hot-Water Piping:
 - 1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 2. Connect to supply connections with shutoff valve, strainer, control valve thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
 - 3. Connect to return connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
 - 4. Make connections with a flange, union, or mechanical coupling.
- J. Basin Heater Steam and Condensate Piping:
 - 1. Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
 - 2. Connect steam supply connection with shutoff valve, strainer, control valve, pressure gage, and flow meter.
 - 3. Connect to condensate connection with shutoff valve, strainer, and an appropriate steam trap assembly.
 - 4. Make connections with a flange or union.

K. Basin Sweeper Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve[, **flow meter**,] and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve[, **flow meter**,] and drain connection with valve.
4. Make connections with a [**flange**][**or**][**union**].

3.4 ELECTRICAL POWER CONNECTIONS

- A. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
- B. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
- C. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
- D. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least **1/2 inch (13 mm)** high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.
- C. Connect control wiring between cooling tower control interface and control system for HVAC for remote monitoring and control of cooling towers. Comply with requirements in [**Section 230923 "Direct Digital Control (DDC) System for HVAC."**]<Insert Section.>
- D. Install label at each termination indicating control equipment designation serving cooling tower and the I/O point designation for each control connection. Comply with requirements in Section 260553 "Identification for Electrical Systems" for labeling and identifying products and installations.

3.6 FIELD TESTING PROVISIONS

- A. Include provisions for cooling tower future field-performance testing complying with [**ASME PTC 23**][**CTI ATC 105**].
- B. Include provisions in field piping for future field-performance testing complying with [**ASME PTC 23**][**CTI ATC 105**].

3.7 FIELD QUALITY CONTROL

- A. Testing Agency:

1. Owner will engage a qualified testing agency to perform tests and inspections.
2. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections: Comply with **[ASME PTC 23][CTI ATC 105]**.
- E. Cooling towers will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.8 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
- B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.
- C. Obtain performance data from manufacturer.
 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Clean entire unit including basins.
 - b. Verify that accessories are properly installed.
 - c. Verify clearances for airflow and for cooling tower servicing.
 - d. Check for vibration isolation and structural support.
 - e. Lubricate bearings.
 - f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
 - g. Adjust belts to proper alignment and tension.
 - h. Verify proper oil level in gear-drive housing. Fill with oil to proper level.
 - i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
 - j. Check vibration switch setting. Verify operation.
 - k. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
 - l. Verify operation of basin heater and control.
 - m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
 - n. Replace defective and malfunctioning units.
- D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.
- E. Prepare a written startup report that records the results of tests and inspections.

3.9 ADJUSTING

- A. Set and balance water flow to each tower inlet.
- B. Adjust water-level control for proper operating level.



- C. Adjust basin heater control for proper operating set point.

3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain cooling towers.
 - 1. Video record the training sessions.
 - 2. Instructor shall be factory trained and certified.
 - 3. Perform not less than **[8]<Insert value>** hours of training.
 - 4. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
 - 5. Perform instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 - 6. Obtain Owner sign-off that training is complete.
 - 7. Owner training shall be held at Project site.

END OF SECTION 23 65 14 14

SECTION 23 65 14 16 - CLOSED-CIRCUIT, INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes factory-assembled, closed-circuit, induced-draft, counterflow cooling towers.

1.2 DEFINITIONS

- A. SCCR: Short-circuit current rating.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, pressure drop, fan performance data, rating at selected points indicated, and furnished specialties and accessories.
 - 2. Maximum flow rate.
 - 3. Minimum flow rate.
 - 4. Pressure required at cooling tower supply piping connections.
 - 5. Pressure required at basin heater supply piping connections.
 - 6. Pressure required at collection basin sweeper supply piping connections.
 - 7. Drift loss as percent of design flow rate.
 - 8. Volume of water in suspension for purposes of sizing remote storage.
 - 9. Sound:
 - a. Sound pressure levels for operation with fan off, fan at minimum speed, and design speed. If sound requirements are indicated at a specific distance, submit performance using same distance for comparative analysis.
 - b. Sound power levels in eight octave bands for operation with fans off, fans at minimum speed, and design speed.
 - 10. Performance curves for the following:
 - a. Varying entering-water temperatures from design to minimum in [one][five]<Insert number>-degree temperature increments.
 - b. Varying ambient wet-bulb temperatures from design to minimum in [one][five]<Insert number>-degree temperature increments.
 - c. Varying water flow rates from design to minimum in increments of [10]<Insert number> percent of flow rate difference between design and minimum flow rates.
 - d. Varying fan operation from design to minimum speed in [5][10]<Insert number> percent speed increments, and with fan off.
 - 11. Fan airflow at design conditions, brake horsepower, and drive losses (indicated in horsepower and percent of brake horsepower).
 - 12. Fan motor electrical characteristics including, but not limited to, speed, voltage, phase, hertz, amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
 - 13. Pump flow rate, head, brake horsepower, and efficiency.
 - 14. Pump motor electrical characteristics including, but not limited to, speed, voltage, phase hertz,

- amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
15. Electrical power requirements for each cooling tower component requiring power.

B. Shop Drawings:

1. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
2. Assembled unit dimensions.
3. Diagram showing each separate piece requiring field assembly.
4. Shipped sub-assembly dimensions and weights for field assembly.
5. Assembled unit weight without water.
6. Operating weight and load distribution.
7. Unit vibration isolation[**and seismic controls**].
8. Required clearances for maintenance and operation.
9. Sizes and dimensioned locations of piping and wiring connections.
10. Diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Design Calculations: Calculate requirements for selecting vibration isolators [**and seismic restraints**][**and wind restraints**] and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Drawings on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Structural supports.
 - b. Piping roughing-in requirements.
 - c. Conduit and wiring roughing-in requirements for controls and electrical power, including spaces reserved for controls and electrical equipment.
 - d. Access requirements, including working clearances for controls and electrical equipment, and service clearances. Mark and label clearances.
2. Drawings showing plans, sections, and elevation views, drawn to scale of at least **<Insert scale>**.
3. Each view to show screened background with the following:
 - a. Structural grids.
 - b. Adjacent walls, floors, and roofs.
 - c. Equipment and products of other trades that are located in vicinity of cooling towers and are part of final installation, such as controls, power, lighting, fire-suppression systems, and plumbing systems.

B. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Product Certificates: For certification required in "Quality Assurance" Article.

D. Field Test Reports: Include startup service reports.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.

B. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Belts:

1. Furnish **[one]<Insert number>** set(s) of matching belts for each unique belt configuration and size furnished.

B. Tool Kit:

1. A tool kit specially designed by cooling tower manufacturer for use in servicing cooling tower(s) furnished.
2. Special tools required to service components not readily available to Owner service personnel in performing routine maintenance.
3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Cooling Tower Tool Kit." Text size shall be at least **1 inch (25 mm)** high.
4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least **1/2 inch (13 mm)** high.

C. Touchup Coating: **[32-oz. (1-L)]<Insert volume>** container of paint coating used. Label outside of container with detailed description of coating to allow for procurement of a matching coating in the future.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: **[Certified by CTI][An NRTL]**.

B. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure



Vessel Code: Section VIII, Division 1.

- C. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.
- D. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Coordinate requirements for multi-piece assembly for shipment. Limit the number of separate pieces for field installation to as few as possible.
- B. If factory assembly of multiple pieces is required for testing or other reasons, disassemble cooling tower into major assemblies as required by installation before packaging for shipment.
 - 1. Clearly label each separate package with a unique designation and include with assembly instructions for each complete cooling tower.
 - 2. Install seals on gear-drive assemblies to eliminate oil leakage during shipment if shipped with oil.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:
 - 1. All components of cooling tower.
 - 2. Fan assembly including fan, drive, and motor.
 - 3. **<Insert components requiring extended warranty>.**
 - 4. Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CLOSED-CIRCUIT, INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Baltimore Aircoil Company]**
 - 2. **[EVAPCO, Inc]**
 - 3. **[Recold]**
 - 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Baltimore Aircoil Company]**
 - 2. **[EVAPCO, Inc]**
 - 3. **[Recold]**
 - 4. **<Insert manufacturer's name>**

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cooling tower support structure[**and seismic restraints**][**and wind restraints**], including comprehensive engineering analysis.
- B. Structural Performance: Cooling tower and support structure shall withstand the effects of loads and stresses within limits and under conditions indicated according to [ASCE/SEI 7][the IBC][governing code]<Insert requirement>.
- C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7]<Insert requirement>.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: [1.5][1.0].
 - 3. Component Amplification Factor: <Insert value>.
 - 4. Component Response Modification Factor: <Insert value>.
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Operation Following Loss of Normal Power:
 - 1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
 - 2. Include means and methods required to satisfy requirement even if not explicitly indicated.
- G. Vibration:
 - 1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry standard requirements for cooling towers.
 - 2. Critical speed shall be at least 115 percent of design speed.

2.3 DESIGN ARRANGEMENT

- A. Counterflow design with airflow from all sides and induced-draft, top-mounted axial fan and pressurized pipe distribution.

2.4 CASING AND FRAME

- A. Casing Material: [Galvanized steel, ASTM A653/A653M, G235 (Z700) coating][Polymer-coated galvanized steel][Stainless steel, Grade 304][Stainless steel, Grade 316]<Insert material>.
- B. Frame Material: [Galvanized steel, ASTM A653/A653M, G235 (Z700) coating][polymer-coated galvanized steel][stainless steel, Grade 304][stainless steel, Grade 316][or][materials to match

casing]<Insert material>.

- C. Hardware: [**Galvanized**][or][**stainless**] steel.
- D. Joints and Seams: Sealed watertight.
- E. Welded Connections: Sealed watertight[**by continuous welds**].

2.5 COLLECTION BASIN

A. Factory-Assembled Collection Basin:

- 1. Material: [**Galvanized steel, ASTM A653/A653M, G235 (Z700) coating**][**Polymer-coated galvanized steel**][**Stainless steel, Grade 304**][**Stainless steel, Grade 316**]<Insert material>.
- 2. Hardware: [**Galvanized**][or][**stainless**] steel.
- 3. Joints and Seams: Sealed watertight.
- 4. Welded Connections: Sealed watertight[**by continuous welds**].
- 5. Removable[**stainless-steel**] strainer with openings smaller than nozzle orifices.
- 6. Overflow and drain connections.
- 7. Makeup-water connection.
- 8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.
- 9. Basin Sweeper Distribution Piping and Nozzles:
 - a. Pipe Material: [**PVC**]<Insert material>, Schedule 40 or heavier, treated with UV inhibitors and intended for continuous exposure to direct sunlight with degradation.
 - b. Nozzle Material: [**Plastic**]<Insert material>.
 - c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.
 - d. Basin penetrations sealed watertight.
 - e. Field Connections: Threaded or flanged depending on pipe size. Threaded for sizes through <Insert pipe size> and flanged for larger sizes.

2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

- A. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
- B. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:
 - 1. Enclosures: NEMA 250, [**Type 4**][**Type 4X**]<Insert Type>.
 - 2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to [**control makeup-water valve**][**control makeup-water valve and low-level alarm**][**control makeup-water valve and low- and high-level alarms**][**control makeup-water valve, low- and high-level alarms, and output for shutoff of pump on low level**].
 - 3. Electrode Probes: Stainless steel.
 - 4. Water Stilling Chamber: [**Corrosion-resistant material**][**FRP**][**Galvanized steel**][**PVC pipe**][**Stainless steel, Grade 304**][**Stainless steel, Grade 316**]<Insert material>.
 - 5. Makeup-Water Valve:
 - a. Slow closing[**with stainless-steel body**].
 - b. Valve actuator controlled and powered through level controller in response to water-level set point.

- c. Actuator Enclosure: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
 - d. Fail Position: **[Closed][Open][Last]**.
 - e. Action: **[Two position][or][modulating]**.
6. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.7 COLLECTION BASIN HEATER

A. Electric Heater:

- 1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
- 2. Heater Control Panel: Mounted on the side of each cooling tower cell.
- 3. Enclosure: NEMA 250, **[Type 3R][Type 4][Type 4X]<Insert Type>**.
- 4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
- 5. Control-circuit transformer with primary and secondary side fuses.
- 6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
- 7. Single-point, field-power connection to a **[fused disconnect switch][nonfused disconnect switch][circuit breaker]** and heater branch circuiting complying with NFPA 70.
- 8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.
 - a. Raceway shall be corrosion-resistant **[stainless steel][or][PVC coated steel]**.

2.8 PRESSURIZED DISTRIBUTION NETWORK

- A. Main header and lateral branch piping designed for even distribution over heat-exchanger coils throughout the entire flow range without the need for balancing valves and for connecting individual, easily removable, nonclogging spray nozzles.
- B. Pipe Material: **[Schedule 40 PVC]<Insert material>**.
- C. Spray Nozzle Material: **[Plastic][Polypropylene][or][PVC]<Insert material>**.
- D. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

2.9 HEAT-EXCHANGER COILS

- A. Tube and Tube Sheet Materials: **[Copper tube with stainless-steel tube sheet][stainless-steel tube and tube sheet][or][carbon-steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication]**.
- B. Heat-Exchanger Arrangement:
 - 1. **[Serpentine tubes][Serpentine tubes with removable cover plate on inlet and outlet headers][or][straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube]**; sloped for complete drainage of fluid by gravity.
 - 2. Tubes with extended surface fins if required to achieve performance indicated.

3. Multiple Separate Circuits: Separate circuits to achieve multiple isolated loops as required by application.
- C. ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and bearing ASME "U" stamp; sloped for complete drainage of fluid by gravity.
- D. Field Piping Connections: Vent, supply, and return[**suitable for mating to ASME B16.5, Class 150 flange**].

2.10 DRIFT ELIMINATORS

- A. Material: **[PVC]<Insert material>**; with maximum flame-spread index of **[5][25]<Insert number>** according to ASTM E84.
- B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
- C. Arrangement: Multiple, easily removable sections.
- D. Configuration: Multipass, designed and tested to reduce water carryover to **[0.001]<Insert number>** percent of design flow rate indicated.
- E. Hardware: **[Galvanized][or][stainless]** steel.

2.11 AIR INLET

- A. Air-Intake Louvers:
 1. Material: **[PVC]<Insert material>**.
 2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
 3. Multiple, easily removable sections arranged to uniformly direct air into cooling tower, to minimize air resistance, to block direct sunlight, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
- B. Hardware: **[Galvanized][or][stainless]** steel.

2.12 FAN AND DRIVE ASSEMBLY

- A. Axial Fan: Balanced at the factory[**after assembly**].
 1. Blade Material: **[Aluminum][FRP][or][galvanized steel]<Insert material>**.
 2. Hub Material: **[Aluminum][FRP][or][galvanized steel]<Insert material>**.
 3. Blade Pitch: Field adjustable.
 4. Fan Shaft: **[Corrosion resistant][Stainless steel]<Insert material>**.
 5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**. Bearings designed for an L-10 life of **[40,000][50,000][100,000]<Insert value>** hours.
 6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
 7. Automatic Bearing Greasing System:

- a. Manufacturer designed system to provide an as needed supply of new grease to bearings while reducing the need for periodic bearing maintenance and associated greasing problems.
 - b. Easily replaceable storage container filled with recommended grease and located in an easily accessible location on cooling tower exterior. Container capacity of sufficient size to provide grease for **[one year]<Insert time period>**.
- B. Belt Drive:
 1. Service Factor: **[1.5]<Insert value>** based on motor nameplate horsepower.
 2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
 3. Belt:
 - a. Multiple V-belt design with a matched set of **[cogged]** belts.
 - b. One-piece, multigrooved, solid-back belt.
 4. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
 5. Belt-Drive Guard: Comply with OSHA regulations.
 6. Two-Motor, Single-Fan Drive:
 - a. Two single-speed motors per fan, one sized for full speed and load and the other sized for **[67]<Insert number>** percent of full-load speed.
 - b. Each motor shall have belt drive and be configured for operation when other motor fails.
 - c. Controls and wiring same as two-speed, two-winding motor.
- C. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.
- D. Fan Motor:
 1. Comply with NEMA MG 1 unless otherwise indicated.
 2. Description: NEMA MG 1, **[Design B]<Insert design>**, as required to comply with capacity and torque characteristics; medium induction motor.
 3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
 4. Motor Enclosure: **[Open dripproof with weather protective cover][totally enclosed][totally enclosed air-over (TEAO)][or][totally enclosed fan-cooled (TEFC)][with epoxy or polyurethane finish]**.
 5. Rotor: Random-wound, squirrel cage.
 6. Energy Efficiency: **[Comply with ASHRAE/IES 90.1][NEMA Premium Efficient]**.
 7. Service Factor: **[1.15]<Insert value>**.
 8. Temperature Rise: **[Match][One class lower than]<Insert requirements>** insulation rating.
 9. Insulation: **[Class F][Class H]<Insert class>**.
 10. Variable-Speed Motors: Inverter-duty rated per NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
 11. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
 12. Severe-Duty Rating:
 - a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
 - b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**.
 - c. Internal Heater: Automatically energized when motor is de-energized.
 - d. Complying with IEEE 841.

13. Motor Base: Adjustable, or other suitable provision[**for adjusting belt tension**].
14. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than **[0.5]<Insert value>** percent of motor nameplate horsepower.

E. Hardware: **[Galvanized][or][stainless]** steel.

2.13 AIR DISCHARGE

A. Fan Discharge Stack:

1. Manufacturer's standard low-profile design.
2. Material: **[Material to match casing]<Insert material>**.
3. Stack Extension: Fabricated to extend above fan deck **<Insert distance>** unless otherwise indicated.
4. Stack Termination: Wire-mesh, **[galvanized-steel][polymer-coated, galvanized-steel][or][stainless-steel]<Insert material>** screens; segmented into multiple removable pie sections and complying with OSHA regulations.

B. Discharge Hood:

1. Hood Configuration: **[Tapered][Straight]**; totally surrounding heat exchanger, pressurized distribution system and drift eliminators; constructed of same material as casing; and having factory-installed **[insulation and]**access doors.
2. Discharge Dampers: Positive-closure, automatic, isolation dampers constructed of **[aluminum][galvanized steel][stainless steel]<Insert material>** with corrosion-resistant linkages and electric actuators with NEMA 250, Type 4X enclosure.
 - a. If not provided with factory controls, field-connect provisions for electrical power and controls to open dampers when pump is energized and close dampers when pump is de-energized.
3. Capacity-Control Dampers: **[Aluminum][Galvanized-steel][Stainless-steel]<Insert material>** dampers, with corrosion-resistant linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.
 - a. If not provided with factory controls, provide field power and controls to operate dampers when pump is energized and close dampers when pump and fan is de-energized.

C. Hardware: **[Galvanized][or][stainless]** steel.

2.14 RECIRCULATING WATER DISTRIBUTION SYSTEM

A. Pump: Close-coupled, single-stage, **[bronze-fitted]**centrifugal pump; with mechanical seal and suitable for outdoor service. Factory install pump with following:

1. Redundant Pump: Same performance as required for primary pump; easily switched and maintained while cooling tower remains operating.
2. Flanges at pump connections to piping.
3. Strainer[, **with blowdown isolation valve,**] installed in piping on suction side of pump.

4. Flow balancing valve in piping on discharge side of pump.

B. Pump Motor:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, [**Design B**]<Insert design>, as required to comply with capacity and torque characteristics; medium induction motor.
3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: [**Open dripproof**][or][**totally enclosed**][and with epoxy or polyurethane finish].
5. Rotor: Random-wound, squirrel cage.
6. Energy Efficiency: [**Comply with ASHRAE/IES 90.1**][**NEMA Premium Efficient**].
7. Service Factor: [**1.15**]<Insert value>.
8. Temperature Rise: [**Match**][**One class lower than**]<Insert requirements> insulation rating.
9. Insulation: [**Class F**][**Class H**]<Insert class>.
10. Severe-Duty Rating:
 - a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
 - b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**.
 - c. Internal Heater: Automatically energized when motor is de-energized.
 - d. Complying with IEEE 841.

C. Piping:

1. Interconnecting collection basin to pump and pressurization distribution system.
 - a. Design delegated to manufacturer.
 - b. External to and supported from cooling tower casing and frame.
 - c. Material: [**Corrosion resistant**][**PVC**]<Insert material>.
 - d. Install flanges at connections to collection basin and pressurized distribution system.
 - e. Drain connection with isolation valve at piping low point if piping does not drain directly into collection basin.
2. Field installed for connection to remotely installed pump and water storage that are not furnished with cooling tower.

2.15 ELECTRICAL POWER

- A. Factory Furnish for Field Installation: A [**disconnect switch**][**motor controller**][**variable-frequency controller**] for each fan motor and a [**disconnect switch**][**motor controller**] for each pump motor.
- B. Factory Install: A [**disconnect switch**][**motor controller**][**variable-frequency controller**] for each fan motor and a [**disconnect switch**][**motor controller**] for each pump motor.
 1. Locate in a convenient and field-accessible location within sight of motor.
 2. Installation shall comply with NFPA 70.
 3. Wire, Conduit, and Enclosures:
 - a. Minimum Conduit Size: [**0.75 inch (20 mm)**]<Insert size>.
 - b. Materials: Corrosion resistant[and constructed of stainless steel or PVC coated steel].
 - c. Motor Termination: Liquidtight conduit, not to exceed **36 inches (900 mm)** long.

- d. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware **[constructed of stainless steel]**.
- e. Wire:
 - 1) Copper, rated for 600-V, solid wire for size **[No. 10 AWG]**<Insert wire size> and smaller and stranded wire for larger sizes.
 - 2) Minimum Wire Size: **[No. 12 AWG]**<Insert wire size>.
 - 3) Each circuit shall have a ground wire.
 - 4) Install wire in conduit.
- f. Boxes, Condulets, and Enclosures: NEMA 250, **[Type 3R][Type 4][Type 4X]**.

C. Disconnect Switches:

- 1. Specification Grade: "Heavy Duty Type"; "quick-make," "quick-break" construction.
- 2. Three pole, **[fused][or][nonfused]**.
- 3. 600 V rated.
- 4. Minimum SCCR: As required by electrical power distribution system, but not less than **[42,000][65,000]**<Insert value> A.
- 5. Enclosure: NEMA 250, **[Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]**<Insert Type>.
- 6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
- 7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
- 8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
- 9. Include a solid neutral as required by authorities having jurisdiction.
- 10. Provide a ground lug for ground wire termination.
- 11. Operating handle shall be lockable in open position.
- 12. Horsepower rated.
- 13. Feed through or double lugged.

D. Motor Controllers:

- 1. NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.
- 2. Configured for control of single- or multispeed motors as indicated.
- 3. Enclosure: NEMA 250, **[Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]**<Insert Type>, with hinged full-front access door with lock and key.
- 4. Externally Operated[, **Door-Interlocked**] Disconnect: **[Fused disconnect switch][Nonfused disconnect switch][Circuit breaker]** with lockable handle.
- 5. SCCR shall be as required by electrical power distribution system, but not less than **[42,000][65,000]**<Insert value> A.
- 6. Hand-Off-Auto Switch: Mounted on face of enclosure.
- 7. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
- 8. Control Relays: Time-delay relays.
- 9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
- 10. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
- 11. Number-of-Starts Counter: Numerical readout on face of enclosure.

E. Variable-Frequency Controllers:

- 1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.

2. Enclosure: Unit mounted, NEMA 250, [Type 3R][Type 4][Type 4X][or][Type 4X stainless steel]<Insert Type>, with hinged full-front access door with lock and key.
3. Externally Operated[, Door-Interlocked] Disconnect: [Fused disconnect switch][Nonfused disconnect switch][Circuit breaker] with lockable handle.
4. Minimum SCCR shall be as required by electrical power distribution system, but not less than [42,000][65,000]<Insert value> A.
5. Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
9. Operating Requirements:
 - a. Input AC Voltage Tolerance: [10]<Insert number> percent.
 - b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - c. Capable of driving full motor load, without derating.
 - d. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - e. Minimum Displacement Primary-Side Power Factor: 95 percent.
 - f. Overload Capability: 1.05 times the full-load current for 7 seconds.
 - g. Starting Torque: As required by fan and motor drive assembly.
 - h. Speed Regulation: 1 percent.
 - i. Speed Range: 10:1 speed range.
 - j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
 - k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
 - a. Overtemperature.
 - b. Short circuit at controller output.
 - c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
 - d. Open circuit at controller output.
 - e. Input undervoltage.
 - f. Input overvoltage.
 - g. Loss of input phase.
 - h. Reverse phase.
 - i. AC line switching transients.
 - j. Instantaneous overload, line to line or line to ground.
 - k. Sustained overload exceeding 100 percent of controller rated current.
 - l. Starting a rotating motor.
 - m. <Insert features>.
12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
13. Automatic Reset and Restart:
 - a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
 - b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

14. Visual Indication: On face of controller; indicating the following conditions:
 - a. Power on.
 - b. Run.
 - c. Overcurrent and overvoltage.
 - d. Motor speed (percent).
 - e. Various faults with alarm status.
 - f. Input kilovolt amperes.
 - g. Power factor.
 - h. Input kilowatts and kilowatt-hours.
 - i. Three-phase input and output voltage.
 - j. Three-phase input and output current.
 - k. Output frequency.
 - l. Elapsed operating time (hours).
 - m. Diagnostic and service parameters.
 - n. **<Insert conditions>**.
15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
16. Control Signal Interface: A minimum of **[two]<Insert value>** analog inputs (0 to 10 V or 0/4 to 20 mA) and **[four]<Insert value>** programmable digital inputs.
17. Bypass Controller:
 - a. Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.
 - b. Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller for safe servicing of variable-frequency controller.
 - c. Include "Bypass/VFC" manual selector switch on face of enclosure for local operator control of preferred controller.
 - d. Include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.
 - e. Install bypass controller in same enclosure as variable-frequency controller.

2.16 CONTROLS

- A. Vibration Switch: For each fan drive.
 1. Enclosure: NEMA 250, **[Type 4][Type 4X]<Insert Type>**.
 2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
 3. Switch shall have manual-reset button hardwired connection to fan motor electrical circuit.
 4. Switch shall have field connection to a control system hardwired connection to fan motor electrical circuit.
 5. Switch shall, on sensing excessive vibration, **[signal an alarm for connection to control system and]** shut down the fan.
- B. Control Package: Factory installed and wired, and functionally tested at factory before shipment.
 1. Factory installed and wired, and functionally tested at factory before shipment.
 2. NEMA 250, **[Type 3R][Type 4][Type 4X]** enclosure with removable internally mount backplate.
 3. Control-circuit transformer with primary and secondary side fuses.

4. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
5. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
6. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
7. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve" Paragraph in "Collection Basin Makeup-Water Assembly" Article.
8. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Collection Basin Heater" Article.
9. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
10. Single-point, field-power connection to a **[fused disconnect switch][nonfused disconnect switch][circuit breaker][for each cooling tower cell]**.
 - a. Branch power circuit to each motor and electric basin heater and to controls[**with a disconnect switch or circuit breaker**].
 - b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
11. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
12. Visual indication of status and alarm[**with momentary test push button**] for each motor.
13. Audible alarm and silence switch.
14. Visual indication of elapsed run time, graduated in hours for each motor.
15. Cooling tower shall have hardware to enable control system to remotely monitor and display the following:
 - a. Operational status of each motor.
 - b. Cooling tower leaving-fluid temperature.
 - c. Fan vibration alarm.
 - d. Collection basin **[high][low][high- and low]**-water-level alarms.
 - e. **<Insert conditions to be monitored>**.

2.17 WATER TREATMENT

- A. Chemical-Free Water Treatment System: Complete factory-installed system consisting of the following:
 1. Pulsed-power technology emitting high-frequency bursts of low energy electromagnetic fields to the recirculated water to control corrosion, bacteria, and scale.
 2. Conductivity control of electrically operated valve designed to control totally dissolved solids levels and bleed rates.
 3. Piping associated with system.
 4. Interconnecting power and control wiring installed in corrosion-resistant metal raceway.
- B. Chemical Water Treatment System: Complete factory-installed system consisting of the following:
 1. Microprocessor-controlled conductivity controller housed in NEMA 250, Type 4X enclosure.
 2. Chemical metering pump housed in NEMA 250, Type 4X enclosure.
 3. Electrically operated valve designed to control totally dissolved solids levels and bleed rates.
 4. Piping associated with system.
 5. Interconnecting power and control wiring installed in corrosion-resistant metal raceway.

2.18 SERVICE ACCESS

- A. Doors:
 - 1. Large enough for personnel to access cooling tower internal components.
 - 2. Doors shall be hinged with handles operable from both sides of the door.
 - 3. Door materials shall match casing.
 - 4. Hinges and handles shall be **[corrosion resistant][stainless steel]<Insert material>**.
- B. External Ladders with Safety Cages: **[Aluminum][galvanized-steel][or][stainless-steel]<Insert material>** fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
- C. External Platforms with Handrails: **[Aluminum][galvanized-steel][or][stainless-steel]<Insert material>** bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
- D. External Motor Platforms with Handrails: **[Aluminum][galvanized-steel][or][stainless-steel]<Insert material>** bar grating.
- E. Fan Deck Floor between Cooling Tower Cells:
 - 1. Factory furnish reinforced fan deck floor panels between cooling tower cells for field installation.
 - 2. Floor materials shall match adjacent cooling tower cell fan deck.
 - 3. Fan deck floor shall fasten to and be supported by framing that is attached to cooling tower cells.
 - 4. Frame shall be constructed of same materials as cooling tower frame.
- F. Handrail: **[Aluminum][galvanized steel][or][stainless steel]<Insert material>** complete with kneerail and toeboard, around external platforms and top of cooling tower. Comply with 29 CFR 1910.23.
- G. Internal Platforms: **[Aluminum][galvanized-steel][or][stainless-steel]<Insert material>** bar grating.
 - 1. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between. Platform shall be elevated so that all parts are above the high water level of the collection basin.
 - 2. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach.
 - 3. **<Insert platform locations>**.
- H. Hardware: Galvanized steel when connecting galvanized-steel components; stainless steel when connecting other materials.

2.19 HOISTING ASSEMBLY

- A. Hoisting assembly consisting of pedestal base, davit arm, and winch to accommodate lowering and raising cooling tower components from their installed location to the base of cooling tower supports.
 - 1. Cooling tower components serviceable by hoisting assembly shall include, but not be limited to, fan stack, fan, fan drive, and fan motor.
 - 2. Hoisting assembly shall be designed to accommodate heaviest single component plus a safety factor of **[1.5]<Insert value>**.
 - 3. Construct cooling tower structural supports and reinforcing to accommodate lifting heaviest load

with safety factor.

B. Pedestal Base:

1. Equip each cooling tower cell with a pedestal base to accommodate an easily removable davit arm and winch assembly.
2. Position pedestal base at a location on cooling tower for hoisting assembly coverage to fan, fan motor, and fan drive assembly.
3. Pedestal base design shall be open-socket, or comparable, design that is configured to accept and secure an inserted portable davit arm.
4. Fit each pedestal base with an easily removable cap or plug designed to seal the open top of the base when the davit arm is not installed.
5. Fasten pedestal base to cooling tower using threaded hardware.
6. Construct pedestal base of **[hot-dip galvanized steel][or][300L series stainless steel]**.

C. Davit Arm:

1. Each cooling tower **[cell]** shall have a davit arm.
2. Davit arm shall be an adjustable telescoping design with angular adjustment to accommodate varying lifting conditions required by the application.
3. Davit arm assembly shall be portable and capable of being relocated to any cooling tower cell pedestal base.
4. Construct davit arm of **[hot-dip galvanized steel][or][300L series stainless steel]**.

D. Winch:

1. Each davit arm shall have **[an electric-][or][a hand-]**operated winch.
 - a. Electric winch shall include a power cord and plug for connection to a field-installed, weatherproof, 20-A receptacle with 120-V, single-phase, 60-Hz field power supply.
 - b. Hand-operated winch with gear mechanism to limit force on handle to not more than **80 lb (36 kg)** when lifting the heaviest component.
2. Coat winch body and exposed components with corrosion-resistant finish that is rated for outdoor duty in a highly corrosive environment and exposed to direct sunlight.
3. Winch cable shall be stainless steel and terminated with a stainless-steel hook and quick disconnecting mechanism. Cable length shall be at least 1.5 times actual length required for application.

E. Hardware: **[304][or][316]** series stainless steel.

F. Nameplate:

1. Stamped or engraved aluminum or stainless-steel nameplate with rated load capacity on each davit arm and pedestal.
2. Letter size legible from a distance of **60 inches (1500 mm)** and not less than **1/2 inch (13 mm)**.
3. Fasten nameplate at multiple points with stainless-steel rivets or screws.

2.20 CAPACITIES AND CHARACTERISTICS

A. Number of Cells: **<Insert quantity>**.

B. Air-Inlet Arrangement: All sides.

C. Maximum Drift Loss: **[0.001]<Insert number>** percent of design water flow.

- D. Heat Exchanger:
1. Fluid Type: **[Water]<Insert type>**.
 2. Design Fluid Flow per Cell: **<Insert gpm (L/s)>**.
 3. Minimum Fluid Flow per Cell: **<Insert gpm (L/s)>**.
 4. Fluid Pressure Drop: **<Insert psig (kPa)>**.
 5. Fluid Pressure Rating: **<Insert psig (kPa)>**.
 6. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
 7. Leaving-Fluid Temperature: **<Insert deg F (deg C)>**.
 8. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 9. Airflow per Cell: **<Insert cfm (L/s)>**.
- E. Economizer-Mode Performance:
1. Fluid Flow per Cell: **<Insert gpm (L/s)>**.
 2. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
 3. Leaving-Fluid Temperature: **<Insert deg F (deg C)>**.
 4. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
- F. Fan Drive Assembly:
1. Type: **[Belt][or][direct]**.
 2. Fan Motor:
 - a. Type: **[Single speed][Two speed, single winding][Two speed, two winding][Variable speed]**.
 - b. Motor Size per Cell: **<Insert number> hp**.
 - c. Full-Load Ampacity: **<Insert value>**.
 - d. Minimum Circuit Ampacity: **<Insert value>**.
 - e. Maximum Overcurrent Protection Device: **<Insert amperage>**.
 - f. Electrical Characteristics: **[208][240][480]<Insert value>-V ac, 3 phase, 60 Hz**.
- G. Pump and Motor:
1. Water Flow per Cell: **<Insert gpm (L/s)>**.
 2. Motor Size per Cell: **<Insert number> hp**.
 3. Full-Load Ampacity: **<Insert value>**.
 4. Minimum Circuit Ampacity: **<Insert value>**.
 5. Maximum Overcurrent Protection Device: **<Insert amperage>**.
 6. Electrical Characteristics: **[120][208][240][277][480]<Insert value>-V ac, [single][3] phase, 60 Hz**.
- H. Sound Pressure Level: **<Insert dBA> at <Insert distance in feet (m)>[when measured according to CTI ATC 128]**.
- I. Collection Basin Heater:
1. Basin Water Temperature: **[40 deg F (5 deg C)]<Insert temperature>**.
 2. Outdoor Ambient Temperature: **[0 deg F (Minus 18 deg C)][Minus 20 deg F (Minus 29 deg C)]<Insert temperature>**.
 3. Capacity/Cell: **<Insert kilowatts>**.
 4. Full-Load Ampacity: **<Insert value>**.
 5. Minimum Circuit Ampacity: **<Insert value>**.
 6. Maximum Overcurrent Protection Device: **<Insert amperage>**.

7. Electrical Characteristics: [208][240][480]<Insert value>-V ac, 3 phase, 60 Hz.

2.21 SOURCE QUALITY CONTROL

- A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS, "Standard for the Certification of Water-Cooling Tower Thermal Performance."
 1. Allow [Owner]<Insert entity> access to place where cooling towers are being tested. Notify Owner in writing at least [30]<Insert number> days in advance of testing.
 2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
- B. Seismic Performance Testing: Shake table tested by an independent[or a factory-certified] laboratory to certify performance complies with seismic requirements indicated.
 1. Allow [Owner]<Insert entity> access to place where cooling towers are being tested. Notify Owner in writing at least [30]<Insert number> days in advance of testing.
 2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
- C. Factory Functional Tests:
 1. Test collection and distribution basins after assembly, and prove free of leaks.
 2. Test factory-installed electric/electronic water-level controls for proper operation.
 3. Test factory-installed electric basin heaters for proper operation.
 4. Test factory-installed fan and drive assemblies for proper operation.
 5. Test factory-installed control package for proper operation.
 6. Test access doors to ensure smooth operation and proper fit.
 7. <Insert additional functional test requirements>.
 8. Allow [Owner]<Insert entity> access to place where cooling towers are being tested. Notify Owner in writing at least [30]<Insert number> days in advance of testing.
 9. Submit report documenting tests performed and results within one week of test date.
- D. Heat-Exchanger Factory Pressure and Leak Tests:
 1. Pneumatically test heat-exchanger assembly while submerged underwater and prove to be free of leaks.
 2. Test pressure equal to [1.5]<Insert value> times rated pressured, but not less than <Insert psig (kPa)>.
 3. Submit report documenting test and results.
- E. Owner Travel Expenses:
 1. Include cost associated with Owner travel expenses to witness testing. Total value attributed to travel expenses shall be clearly indicated.
 2. Expenses shall include round-trip coach airfare, out of town hotel accommodations, out of town meals (breakfast, lunch, and dinner), out of town ground transportation, and all associated taxes and fees.
 3. Exclude other incidental expenses not indicated.
 4. Include travel expenses for [one][two]<Insert value> Owner representative(s) with origin of <Insert city, state, and country>.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine cooling towers before installation. Reject cooling towers that are damaged.
- B. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting cooling tower performance, maintenance, and operation.
 - 1. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.
 - 2. Verify sizes and locations of concrete bases and support structure with actual equipment.
 - 3. Verify sizes, locations, and anchoring attachments of structural-steel support structures.
 - 4. Verify sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install cooling towers on support structure.
- B. Equipment Mounting:
 - 1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Maintain manufacturer's recommended clearances for service and maintenance.
- E. Maintain clearances required by governing code.
- F. Loose Components: Install components, devices, and accessories furnished by manufacturer with cooling tower, that are not factory mounted.
 - 1. Loose components shall be installed by **[manufacturer's factory-trained service personnel][Contractor under supervision of manufacturer's factory-trained service personnel]**.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.
- C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.
- D. Install drain piping with valve at cooling tower drain connections and at low points in piping.
- E. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.
- F. Makeup-Water Piping:
 - 1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
 - 2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, [**flow meter**,] and drain connection with valve and union.
- G. Supply and Return Piping:
 - 1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 2. Connect to entering cooling tower connections with shutoff valve, [**strainer**,] balancing valve, thermometer, plugged tee with pressure gage, [**flow meter**,] and drain connection with valve.
 - 3. Connect to leaving cooling tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
 - 4. Make connections to cooling tower with a flange.
- H. Basin Sweeper Piping:
 - 1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 2. Connect to supply connections with shutoff valve, [**flow meter**,] and drain connection with valve.
 - 3. Connect to return connections with shutoff valve, balancing valve, [**flow meter**,] and drain connection with valve.
 - 4. Make connections with a [**flange**][**or**][**union**].

3.4 ELECTRICAL POWER CONNECTIONS

- A. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
- B. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
- C. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
- D. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least **1/2 inch (13 mm)** high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between cooling towers and other equipment to interlock operation as required to

achieve a complete and functioning system.

- C. Connect control wiring between cooling tower control interface and **[DDC system]<Insert system description>** for remote monitoring and control of cooling towers. Comply with requirements in **[Section 230923 "Direct Digital Control (DDC) System for HVAC."]<Insert Section.>**
- D. Install label at each termination indicating control equipment designation serving cooling tower and the I/O point designation for each control connection. Comply with requirements in Section 260553 "Identification for Electrical Systems" for labeling and identification products and installations.

3.6 FIELD TESTING PROVISIONS

- A. Include provisions for cooling tower future field-performance testing complying with **[ASME PTC 23][CTI ATC 105]**.
- B. Include provisions in field piping for future field-performance testing complying with **[ASME PTC 23][CTI ATC 105]**.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections **[with the assistance of a factory-authorized service representative]**.
- D. Tests and Inspections: Comply with **[ASME PTC 23][CTI ATC 105]**.
- E. Cooling towers will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.8 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
- B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.
- C. Obtain performance data from manufacturer.
 - 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Clean entire unit including basins.
 - b. Verify that accessories are properly installed.

- c. Verify clearances for airflow and for cooling tower servicing.
 - d. Check for vibration isolation and structural support.
 - e. Lubricate bearings.
 - f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
 - g. Verify pump rotation for correct direction, vibration, cavitation, and flow and correct problems.
 - h. Adjust belts to proper alignment and tension.
 - i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
 - j. Check vibration switch setting. Verify operation.
 - k. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
 - l. Verify operation of basin heater and control.
 - m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
 - n. Replace defective and malfunctioning units.
- D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.
- E. Prepare a written startup report that records the results of tests and inspections.

3.9 ADJUSTING

- A. Set and balance water flow to each tower inlet.
- B. Adjust water-level control for proper operating level.
- C. Adjust basin heater control for proper operating set point.

3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain cooling towers.
 - 1. Video record the training sessions.
 - 2. Instructor shall be factory trained and certified.
 - 3. Perform not less than **[8]<Insert value>** hours of training.
 - 4. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
 - 5. Perform instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 - 6. Obtain Owner sign-off that training is complete.
 - 7. Owner training shall be held at Project site.

END OF SECTION 23 65 14 16



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 71 13 23	22 12 23 26	Facility Fuel-Oil Piping
23 71 13 23	23 11 26 00	Facility Liquefied-Petroleum Gas Piping



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 72 13 00 - HEAT WHEEL AIR-TO-AIR ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Heat wheel air-to-air energy recovery units.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for air-to-air energy recovery units.
2. Section 237313.19 "Indoor, Custom Air-Handling Units" for custom housings used for air-to-air energy recovery units.
3. Section 237343.19 "Outdoor, Custom Air-Handling Units" for custom housings used for air-to-air energy recovery units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For air-to-air energy recovery equipment.

1. Include plans, elevations, sections, details, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittals: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-to-air energy recovery equipment.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
3. Design Calculations: Calculate requirements for selecting vibration isolators **[and seismic restraints]** and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
 - 2. Support location, type, and weight.
 - 3. Field measurements.
- B. Seismic Qualification Data: Certificates, for air-to-air energy recovery equipment, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Wheel Belts: [**One**]**<Insert number>** set(s) of belts for each heat wheel.

1.6 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
 - 1. **<Insert components requiring extended warranty>**.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.
- C. ASHRAE Compliance:
 - 1. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
 - 2. Capacity ratings for air-to-air energy recovery equipment are to comply with ASHRAE 84, "Method of Testing Air-to-Air Heat/Energy Exchangers."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Seismic Performance: Air-to-air energy recovery equipment is to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Exhaust Air:
 - 1. Airflow: **<Insert value> cfm (L/s)**.
 - 2. Face Velocity: **<Insert value> fpm (m/s)**.
 - 3. Summer:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C)**.
 - b. Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C)**.
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C)**.
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C)**.
 - 4. Winter:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C)**.
 - b. Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C)**.
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C)**.
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C)**.

5. Air Pressure Drop: **<Insert value> inches wg (Pa).**

B. Supply Air:

1. Airflow: **<Insert value> cfm (L/s).**
2. Face Velocity: **<Insert value> fpm (m/s).**
3. Summer:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - b. Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
4. Winter:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - b. Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
5. Air Pressure Drop: **<Insert value> inches wg (Pa).**

C. Wheel Drive:

1. Motor Size: **<Insert horsepower>.**
2. Motor Electrical Characteristics:
 - a. Volts: **[120][208][230]<Insert value> V.**
 - b. Phase: **[Single][Three].**
 - c. Hertz: 60 Hz.

D. Effectiveness: <Insert percentage>.

2.3 HEAT WHEEL AIR-TO-AIR ENERGY RECOVERY UNITS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. **[AIRotor, LLC]**
2. **[Airxchange Inc.]**
3. **[Desiccant Rotors International, Inc.]**
4. **[Heatex, Inc.]**
5. **[Klingenburg]**
6. **[Novelair Technologies]**
7. **[SEMCO, LLC; part of FlaktGroup]**
8. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. **[AIRotor, LLC]**
2. **[Airxchange Inc.]**

3. [Desiccant Rotors International, Inc.]
4. [Heatex, Inc.]
5. [Klingenburg]
6. [Novelaire Technologies]
7. [SEMCO, LLC; part of FlaktGroup]
8. <Insert manufacturer's name>

C. Source Limitations: Obtain from single source from single manufacturer.

2.4 HEAT WHEELS

A. Casing:

1. Galvanized steel, stainless steel, or aluminum with standard factory finish.
2. Integral purge section limiting carryover of exhaust air to between **[0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa)]<Insert value>** differential pressure.
3. Casing seals on periphery of rotor and on duct divider and purge section.
4. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings[**or permanently lubricated bearings**] with an **[L-10]<Insert bearing life>[400,000 hours]<Insert hours>**. Support horizontal rotors on tapered roller bearing.
5. Rotor:
 - a. Aluminum or polymer segmented wheel strengthened with radial spokes[, **with nontoxic, noncorrosive, silica-gel desiccant coating**].
 - b. Aluminum, metallic, or polymer segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom, molecular-sieve desiccant coating.

B. Drive: Fractional horsepower motor and gear reducer[, **with speed changed by variable-frequency controller**] and self-adjusting multilink belt around outside of rotor.

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

C. Controls:

1. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
2. Variable-Frequency Controller: Factory mounted and wired, permitting input of field-connected 4- to 20-mA or 1- to 10-V control signal.
3. Variable-Frequency Controller with Exhaust-Air Sensor: Factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
4. Variable-Frequency Controller with Exhaust- and Outdoor-Air Sensors: Factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain[**exhaust temperature above freezing and**] air differential temperature above set point. Rotor speed is to increase to maximum when exhaust-air temperature is less than outdoor-air temperature.
5. Pilot-Light Indicator: Display rotor rotation and speed.
6. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
7. **<Insert additional control features>**.

2.5 SOURCE QUALITY CONTROL

- A. AHRI 1060 Certification: Testing in accordance with AHRI 1060 and listed and labeled by AHRI.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical services to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HEAT WHEELS

- A. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.
 - 1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
 - 2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
 - 3. Access doors and panels are specified in Section 233300 "Air Duct Accessories."
- B. Install floor-mounted units on **4-inch- (100-mm-)** high concrete base[**designed to withstand, without damage to equipment, seismic force required by code**].
- C. Equipment Mounting:
 - 1. Install air-to-air energy recovery equipment on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- D. Install seismic restraints in accordance with manufacturers' written instructions.
- E. Suspended Units: Suspend[**and brace**] units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- F. Install units with clearances for service and maintenance.
- G. Comply with requirements for ductwork specified in Section 233113 "Metal Ducts."

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Where installing piping adjacent to unit, allow space for service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Condensate Drain Piping:
 - 1. Pipe drains from drain pans to nearest floor drain; use **ASTM B88, Type L (ASTM B88M, Type B)**, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.
 - 2. Pipe drains from drain pans to nearest floor drain; use ASTM D1785, Schedule 40 PVC pipe and solvent-welded fittings, same size as condensate drain connection.
- E. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Adjust seals and purge.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 4. Set initial temperature and humidity set points.
 5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Verify that shipping, blocking, and bracing are removed.
 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 4. Verify proper motor rotation direction, wheel rotation, and smooth bearing operations. Reconnect motor drive system, align belts, and install belt guards.
 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.

3.8 ADJUSTING

- A. Comply with requirements for air-handling system testing, adjusting, and balancing in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 23 72 13 00



SECTION 23 72 16 00 - HEAT PIPE AIR-TO-AIR ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes heat-pipe heat exchangers.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Sustainable Design Submittals:
 - 1. Product data showing compliance with ASHRAE 62.1.
- C. Shop Drawings: For air-to-air energy recovery equipment.
 - 1. Include plans, elevations, sections, and [mounting][attachment] details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- D. Delegated-Design Submittal: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of air-to-air energy recovery equipment.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
 - 2. Support location, type, and weight.
 - 3. Field measurements.
- B. Seismic Qualification Data: Certificates, for air-to-air energy recovery equipment, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean, dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breakage, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 - 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 - 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
 - 3. Replace installed products damaged during construction.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Heat Pipe Energy Recovery Equipment: **[Two]<Insert number>** years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NPFA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

- C. ASHRAE Compliance:
1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
 2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat/Energy Exchangers."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to detail fabrication and assembly of air-to-air energy recovery equipment.
- F. Seismic Performance: Air-to-air energy recovery equipment shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7]<Insert requirement>.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Component Importance Factor: [1.5][1.0].
 3. <Insert requirements for Component Amplification Factor and Component Response Modification Factor>.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Exhaust Air:
1. Airflow: <Insert number> cfm (L/s).
 2. Face Velocity: <Insert number> fpm (m/s).
 3. Summer:
 - a. Entering-Air Temperature, Dry Bulb: <Insert number> deg F (deg C).
 - b. Entering-Air Temperature, Wet Bulb: <Insert number> deg F (deg C).
 - c. Leaving-Air Temperature, Dry Bulb: <Insert number> deg F (deg C).
 - d. Leaving-Air Temperature, Wet Bulb: <Insert number> deg F (deg C).
 4. Winter:
 - a. Entering-Air Temperature, Dry Bulb: <Insert number> deg F (deg C).
 - b. Entering-Air Temperature, Wet Bulb: <Insert number> deg F (deg C).
 - c. Leaving-Air Temperature, Dry Bulb: <Insert number> deg F (deg C).
 - d. Leaving-Air Temperature, Wet Bulb: <Insert number> deg F (deg C).
 5. Air Pressure Drop: <Insert number> inches wg (Pa).
- B. Supply Air:
1. Airflow: <Insert number> cfm (L/s).
 2. Face Velocity: <Insert number> fpm (m/s).
 3. Summer:
 - a. Entering-Air Temperature, Dry Bulb: <Insert number> deg F (deg C).
 - b. Entering-Air Temperature, Wet Bulb: <Insert number> deg F (deg C).
 - c. Leaving-Air Temperature, Dry Bulb: <Insert number> deg F (deg C).
 - d. Leaving-Air Temperature, Wet Bulb: <Insert number> deg F (deg C).

4. Winter:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert number> deg F (deg C).**
 - b. Entering-Air Temperature, Wet Bulb: **<Insert number> deg F (deg C).**
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert number> deg F (deg C).**
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert number> deg F (deg C).**
5. Air Pressure Drop: **<Insert number> inches wg (Pa).**

C. Tilt Motor:

1. Horsepower: **<Insert number> hp.**
2. Electrical Characteristics:
 - a. Volts: **<Insert number> V.**
 - b. Phase: **<Insert number>.**
 - c. Hertz: **[60]<Insert number> Hz.**

D. Effectiveness: **<Insert percentage>.**

2.3 HEAT-PIPE HEAT EXCHANGERS

A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Engineered Air]**
2. **[Heat Pipe Technology, Inc.]**
3. **[Innergy Tech, Inc.]**
4. **<Insert manufacturer's name>**

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Engineered Air]**
2. **[Heat Pipe Technology, Inc.]**
3. **[Innergy Tech, Inc.]**
4. **<Insert manufacturer's name>**

C. Casing: **[Galvanized][Stainless]-steel flanged casing, with airtight [single][double] partition between airstreams.**

D. Refrigerant: **[ASHRAE 34, Safety Group 1]<Insert refrigerant>.**

E. Tubes:

1. Tube Diameter: **<Insert dimension> diameter.**
2. Tube Material: **[Aluminum][Copper]<Insert material>.**
3. Number of Tube Rows: As required to meet scheduled capacity conditions.

F. Fins: **<Insert material>.**

1. Fin Spacing: As required to meet scheduled capacity conditions.

- 2. Fin and Tube Joint: [**Mechanical bond**][**Silver brazed**].
- G. Coating: [**None**][**Flexible epoxy polymer e-coating**][**Baked phenolic**]**<Insert coating>**; apply to supply and exhaust.
- H. Control:
 - 1. Integral plenum containing heat-pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.
 - 2. Pivot center of bottom of heat-pipe coil on shaft and bearings to tilt coil. Include tilt controls with electronic controller, electric actuator and linkage, thermostats, sensors, and polyester fabric with PVC-coated flexible connector for automatic supply temperature regulation, summer/winter changeover, and frost protection.

2.4 SOURCE QUALITY CONTROL

- A. AHRI Certification: Certified according to AHRI 410.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical services to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install heat-pipe heat exchangers so supply and exhaust airstreams flow in opposite directions.[**Install flexible connectors on ducts to enable tilt control; make connections airtight and with slack to compensate for full tilt.**]
 - 1. Install heat exchanger with clearance space for heat-pipe coil removal.
 - 2. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to both sides of heat-pipe coil. Access doors and panels are specified in Section 233300 "Air Duct Accessories."
 - 3. Install tilt-control components, including electronic controller, electric actuator and linkage, thermostats, and sensors.
- B. Install floor-mounted units on **4-inch- (100-mm-)** high, concrete base[**designed to withstand, without damage to equipment, seismic force required by code**].
- C. Equipment Mounting:
 - 1. Install air-to-air energy recovery equipment on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

- D. Install seismic restraints according to manufacturers' written instructions.
- E. Install units with clearances for service and maintenance.

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to unit, allow space for service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Condensate Drain Piping:
 - 1. Pipe drains from drain pans to nearest floor drain; use **ASTM B88, Type L (ASTM B88M, Type B)**, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.
 - 2. Pipe drains from drain pans to nearest floor drain; use ASTM D1785, Schedule 40 PVC pipe and solvent-welded fittings, same size as condensate drain connection.
- E. Condensate Drain Piping Installation: Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260529 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished with units, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency:

1. Owner will engage a qualified testing agency to perform tests and inspections.
2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper tilt control and unit operation.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Verify that shipping, blocking, and bracing are removed.
 3. Verify that unit is secure on mountings and supporting devices and that connections to electrical systems are complete. Verify that proper thermal-overload protection is installed.
 4. Verify tilt mechanism operation.
 5. Verify that moving parts are lubricated with factory-recommended lubricants.
- B. Starting procedures for air-handling units include the following:
 1. Energize actuator motor and verify proper operation of motor and tilt system.
 2. Measure and record motor electrical values for voltage and amperage.
 3. Operate bypass dampers from full closed to fully open position.

3.8 ADJUSTING

- A. Adjust tilt mechanism for proper operation.
- B. Adjust bypass dampers for proper operation.
- C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.9 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-to-air heat recovery unit, **and after completing startup service,** clean unit to remove foreign material and construction dirt and dust.

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain heat pipe air-to-air energy recovery units.

END OF SECTION 23 72 16 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 72 16 00	23 72 13 00	Heat Wheel Air-To-Air Energy Recovery Units



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 73 00 00 - INDOOR, INDIRECT, GAS-FIRED HEATING AND VENTILATING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Indoor, indirect, gas-fired heating and ventilating units.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each indoor, indirect, gas-fired heating and ventilating unit.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - c. Include unit dimensions and weight.
 - d. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - e. Fans:
 - 1) Include certified fan-performance curves with system operating conditions indicated.
 - 2) Include certified fan-sound power ratings.
 - 3) Include fan construction and accessories.
 - 4) Include motor ratings, electrical characteristics, and motor accessories.
 - 5) Include fan speed controllers.
 - f. Include material thickness and finishes, including color charts.
 - g. Include filters with performance characteristics.
 - h. Include direct, gas-fired burners with performance characteristics.
 - i. Include dampers, including housings, linkages, and operators.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each type and configuration of indoor, indirect, gas-fired heating and ventilating unit.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures



and diagrams.

4. Include diagrams for power, signal, and control wiring.

- D. Delegated Design Submittal: For vibration isolation[, **supports**][and **seismic restraints**] indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators[, **supports**][and **seismic restraints**] and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty.
- C. Seismic Qualification Data: Certificates for indoor, indirect, gas-fired heating and ventilating units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Restraint of internal components.
- D. Startup service reports.
- E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For indirect, gas-fired heating and ventilating units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: **[One]<Insert number>** set(s) for each unit.
 2. Gaskets: **[One]<Insert number>** set(s) for each access door.
 3. Fan Belts: **[One]<Insert number>** set(s) for each unit.

1.6 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of indirect, gas-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than **[one]<Insert number>** year(s) from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[, **supports,**][**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Seismic Performance: Indoor, indirect gas-fired, heating and ventilating units shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Fan:
 1. Discharge Configuration: **[Horizontal][Vertical]**.
 2. Airflow: **<Insert cfm (L/s)>**.
 3. Total Static Pressure: **<Insert number> inches wg (Pa)**.
 4. External Static Pressure: **<Insert inches wg (kPa)>**.
 5. Maximum RPM: **<Insert number>**.
 6. Minimum Size: **<Insert inches (mm)>**.
 7. Altitude: **<Insert ft. (m)>**.
- B. Fan Motor:
 1. Horsepower: **<Insert value>**.

2. RPM: **<Insert value>**.
3. Service Factor: **<Insert value>**.
4. Speed: **[Single][Two]**.

C. Single-Point Electrical Connection:

1. Volts: **[120][240][277][480]<Insert value> V**.
2. Phase: **[Single][Three]**.
3. Hertz: 60.
4. Full-Load Amperes: **<Insert value> A**.
5. Minimum Circuit Ampacity: **<Insert value> A**.
6. Maximum Overcurrent Protection: **<Insert value> A**.

D. Indirect-Fired Gas Burner:

1. Minimum Combustion Efficiency: **<Insert number> percent**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Airflow: **<Insert cfm (L/s)>**.
5. Gas Input: **<Insert MBh (kW)>**.
6. Burner Output: **<Insert MBh (kW)>**.
7. Number of Stages: **<Insert value>**.
8. Minimum Inlet Pressure: **<Insert inches wg (Pa)>**.
9. Maximum Inlet Pressure: **<Insert inches wg (Pa)>**.
10. Gas Piping Connection Size: **<Insert NPS (DN)>**.
11. Vent Diameter: **<Insert inches (mm)>**.

E. Filters:

1. Type: **<Insert type>**.
2. Face Dimensions, each: **<Insert inches by inches (mm by mm)>**.
3. Depth: **<Insert inches (mm)>**.
4. Number of Filters in Filter Bank: **<Insert number> wide by <Insert number> high**.
5. Access Location: **[Side]<Insert location>**.
6. Maximum or Rated Face Velocity: **<Insert fpm (m/s)>**.
7. Initial Resistance: **<Insert inches wg (Pa)>**.
8. Recommended Final Resistance: **<Insert inches wg (Pa)>**.
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating and Corresponding Average Arrestance: **[MERV 1][MERV 2][MERV 3][MERV 4]**, and corresponding average arrestance according to ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 13]<Insert value>**, according to ASHRAE 52.2.

2.3 INDOOR, INDIRECT, GAS-FIRED HEATING AND VENTILATING UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[AbsolutAire, Inc.]**
2. **[Applied Air, a Mestek company]**

3. [Banza; a brand of Specified Air Solutions]
4. [BessamAire, Inc.]
5. [Cambridge Air Solutions]
6. [Cambridge Engineering, Inc]
7. [CaptiveAire Systems]
8. [Des Champs Technologies]
9. [Energy Jet U.S.]
10. [Engineered Air]
11. [Greenheck Fan Corporation]
12. [Hastings HVAC]
13. [I.C.E. Manufacturing Ltd.; Industrial Commercial Equipment - I.C.E. (US), Inc.]
14. [Jackson & Church HVAC Global]
15. [LCSysytems]
16. [Modine Manufacturing Company]
17. [Nortek Air Solutions]
18. [Powrmatic, Inc.]
19. [Rapid Engineering, Inc.]
20. [REZNOR, a brand of Nortek Global HVAC]
21. [Sterling HVAC Products; a Mestek company]
22. [Temprite, a brand of Mestek]
23. [Titan Air]
24. [Trane]
25. [Weather-Rite, a brand of Specified Air Solutions]
26. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [AbsolutAire, Inc.]
2. [Applied Air, a Mestek company]
3. [Banza; a brand of Specified Air Solutions]
4. [BessamAire, Inc.]
5. [Cambridge Air Solutions]
6. [Cambridge Engineering, Inc]
7. [CaptiveAire Systems]
8. [Des Champs Technologies]
9. [Energy Jet U.S.]
10. [Engineered Air]
11. [Greenheck Fan Corporation]
12. [Hastings HVAC]
13. [I.C.E. Manufacturing Ltd.; Industrial Commercial Equipment - I.C.E. (US), Inc.]
14. [Jackson & Church HVAC Global]
15. [LCSysytems]
16. [Modine Manufacturing Company]
17. [Nortek Air Solutions]
18. [Powrmatic, Inc.]
19. [Rapid Engineering, Inc.]
20. [REZNOR, a brand of Nortek Global HVAC]
21. [Sterling HVAC Products; a Mestek company]
22. [Temprite, a brand of Mestek]
23. [Titan Air]
24. [Trane]
25. [Weather-Rite, a brand of Specified Air Solutions]
26. <Insert manufacturer's name>

- C. Unit Casings:

1. General Fabrication Requirements for Casings:
 - a. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
 - b. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
 - c. Heating and Ventilating Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
2. Configuration: **[Horizontal][Vertical]** unit with **[top][horizontal][bottom]** discharge for **[floor-mounted][suspended]** installation.
 - a. Discharge Section, for Vertically Configured Units: **[Galvanized][Aluminized]**-steel assembly with **[gravity][individually adjustable, vaned,][two-position, motorized,]** parallel-blade dampers with nylon bushings.
 - 1) Pattern: **[Single][Double]** deflection.
 - 2) Leakage: **[Standard][Low]** leakage.
 - b. Discharge Section, Cowls: Trapezoidal cowls with horizontal louvers.
 - c. Discharge Section, Plenum: Plenum with **[two][four]** sides louvered.
 - d. Discharge Section, Down-Discharge: Down-discharge plenum insulated with **1-inch (25-mm), 1.5-lb/cu. ft. (24.0-kg/cu. m)** fibrous glass.
3. Single-Wall Construction:
 - a. Material: **[Galvanized-steel][or][aluminized-steel]<Insert material>** with **[manufacturer's standard finish]<Insert special coating>**.
 - b. Floorplate: **[Galvanized steel]<Insert material>**, minimum **[18 gauge (1.3 mm)]<Insert value>** thick.
 - c. Insulation and Adhesive:
 - 1) Materials: **[ASTM C1071, Type I or Type II glass-fiber blanket or board insulation, neoprene coated or foil faced]<Insert insulation type>**.
 - 2) Insulation R-Value: Minimum **<Insert value>**.
 - 3) Insulation Thickness: **[1 inch (25 mm)]<Insert dimension>**.
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
 - 5) Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of **[complete unit][burner and fan sections only]**.
 - a) Insulation Adhesive: Comply with ASTM C916, Type I.
 - b) Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.
4. Double-Wall Construction:
 - a. Outside Casing Wall: **[Galvanized steel]<Insert material>**, minimum **[18 gauge (1.3 mm)]<Insert value>** thick, with **[manufacturer's standard finish]<Insert special coating>**.
 - b. Inside Casing Wall:
 - 1) Inside Casing, Burner Section: **[Galvanized steel]<Insert material>**, solid, minimum **[14-gauge (0.759-mm)]<Insert number>** thick steel.
 - 2) Inside Casing, All Other Sections: **[Galvanized steel]<Insert**

material>[solid][perforated] steel.

- c. Floor Plate: **[Galvanized steel]<Insert material>**, minimum **[18 gauge (1.3 mm)]<Insert value>** thick.
 - d. Casing Insulation:
 - 1) Materials: **[Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071]<Insert insulation type>**.
 - 2) Casing Panel R-Value: Minimum **<Insert value>**.
 - 3) Insulation Thickness: **[1 inch (25 mm)][2 inches (50 mm)]**.
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
 - e. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
5. Panels, Doors, and Windows:
- a. Panels:
 - 1) Fabrication: Formed and reinforced, with same materials and insulation thickness as casing.
 - 2) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.
 - b. Doors:
 - 1) Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.
 - c. Windows:
 - 1) Construction: Fabricate windows in access panels and doors of double-glazed, safety glass with an air space between panes and sealed with interior and exterior rubber seals.
 - 2) Size: Minimum **[6 inches (150 mm)]<Insert dimension>**, square or round.
 - d. Locations and Applications:
 - 1) Fan Section: **[Inspection and access panels][Doors][, with windows]**.
 - 2) Access Section: Doors**[, with windows]**.
 - 3) Gas-Fired Burner Section: **[Inspection and access panels][Doors]**.
 - 4) Damper Section: **[Inspection and access panels][Doors][, with windows]**.
 - 5) Filter Section: **[Inspection and access panels][Doors]** large enough to allow periodic removal and installation of filters.
 - 6) Mixing Section: Doors**[, with windows]**.

- e. Service Light: 100-W vaporproof fixture with switched junction box located [outside][inside] adjacent to door.

- 1) Locations: [Each section accessed with door][Fan section]<Insert location>.

D. Fan, Drive, and Motor:

1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
2. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - b. Shaft Bearings: Heavy-duty[, **self-aligning, permanently lubricated ball bearings**][, **pillow-block bearings**] with an [L50]<Insert bearing life rating> rated life of [100,000]<Insert number> hours according to ABMA 9.
 - c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - d. Mounting: For internal vibration isolation[**and seismic control**]. Factory-mount fans with manufacturer's standard[**restrained**] vibration isolation mounting devices having a minimum static deflection of [1 inch (25 mm)]<Insert dimension>.
 - e. Shaft Lubrication Lines: Extended to a location outside the casing.
 - f. Flexible Connector: Factory fabricated with a fabric strip minimum **3-1/2 inches (89 mm)** wide, attached to two strips of minimum **2-3/4-inch- (70-mm-)** wide by **0.028-inch- (0.7-mm-)** thick, galvanized-steel sheet.
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
3. Drive: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with [1.5][1.25] service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; [0.146-inch- (2.7-mm-)]<Insert dimension> thick, [3/4-inch (20-mm)]<Insert dimension> diamond-mesh wire screen, welded to steel angle frame; prime coated.
4. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Maximum sizes as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure: [Open, dripproof][Totally enclosed, fan cooled]<Insert type>.
 - d. Enclosure Materials: [Cast iron]<Insert material>.
 - e. Motor Bearings: <Insert requirements>.
 - f. Unusual Service Conditions:
 - 1) Ambient Temperature: <Insert deg C>.
 - 2) Altitude: <Insert ft. (m)> above sea level.
 - 3) High humidity.
 - 4) <Insert conditions>.

- g. Efficiency: Premium efficient as defined in NEMA MG 1.
- h. NEMA Design: **<Insert designation>**.
- i. Motor Pulleys: Adjustable pitch for use with **[5]<Insert number>**-hp motors and smaller; fixed pitch for use with motors larger than **[5]<Insert number>** hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.

E. Air Filtration:

- 1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- 2. Panel Filters:
 - a. Description: **[Flat, non-pleated][Pleated]** factory-fabricated, self-supported, disposable air filters with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
 - d. Filter-Media Frame: **[Beverage board]<Insert material>** with perforated metal retainer, or metal grid, on outlet side.
- 3. Cleanable Filters:
 - a. Cleanable metal mesh.
- 4. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
- 5. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- 6. Side-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. **[Galvanized-steel]<Insert material>** track.
 - 1) Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

F. Dampers:

- 1. Comply with requirements in Section 230923.12 "Control Dampers."
- 2. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, **[galvanized-steel]<Insert material>** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **[opposed][parallel]**-blade arrangement with **[zinc-plated]** steel operating rods rotating in **[sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel]<Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed **[4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa), leakage Class 1]<Insert requirement>**, **tested, rated, and labeled in accordance with AMCA 511**.
- 3. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
- 4. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - c. Operator Motors:

- 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
- d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
- e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
- f. Size dampers for running torque calculated as follows:
- 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft. (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
- g. Coupling: V-bolt and V-shaped, toothed cradle.
- h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
- i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
- j. Power Requirements (Two-Position Spring Return): **[24 V dc][120 V ac][230 V ac]**.
- k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
- l. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
- m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.
- n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.

G. Indirect-Fired Gas Burner:

1. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54.
2. CSA Approval: Designed and certified by and bearing label of CSA.
3. Burners: **[Aluminized steel with stainless steel inserts][Stainless steel]**.
 - a. Rated minimum turndown ratio: **[30 to 1]<Insert ratio>**.
 - b. Fuel: **[Natural][Propane]** gas.
 - c. Ignition: Electronically controlled electric spark with flame sensor.
 - d. Gas Control Valve: **[Single stage][Two stage][Modulating]**.
 - e. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, **[hydraulic][electronic]**-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - f. High-Altitude Model Kit: For Project elevations more than **2000 ft. (610 m)** above sea level.

4. Venting, Gravity: Gravity vented.
5. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.
6. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.
7. Heat Exchanger: **[Aluminized][Stainless]** steel.
8. Heat-Exchanger Drain Pan: Stainless steel.
9. Safety Controls:
 - a. Gas Manifold: Safety switches and controls complying with ANSI standards **[and][FM Global]<Insert insurer>**.
 - b. Vent Flow Verification: **[Differential pressure switch to verify open vent][Flame rollout switch]**.
 - c. High Limit: Thermal switch or fuse to stop burner.
 - d. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
 - e. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
 - f. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - g. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
 - h. Control Transformer: 24 V ac.

H. Unit Control Panel:

1. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
2. Control Panel: **[Surface-mounted][Recessed, with trim ring,]** remote panel, with engraved plastic cover, and the following lights and switches:
 - a. **[On-off][On-off-auto]** fan switch.
 - b. Heat-vent-off switch.
 - c. Supply-fan operation indicating light.
 - d. Heating operation indicating light.
 - e. Thermostat.
 - f. Damper position potentiometer.
 - g. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
 - h. Safety-lockout indicating light.
 - i. Enclosure: NEMA 250, **[Type 1][Type 3R][Type 4][Explosion proof]**.

I. Controls:

1. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.
2. Control Devices:
 - a. Remote Thermostat: Adjustable room thermostat with temperature readout.
 - b. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
 - c. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - d. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than **75 deg F (24 deg C)** above normal maximum operating temperature.
 - e. Timers, Seven Day:
 - 1) Programming-switch timer with synchronous-timing motor and seven-day dial.
 - 2) Continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover.

- 3) Multiple-switch trippers.
- 4) Minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
- f. Timers, Solid State:
 - 1) Programmable time control with four separate programs.
 - 2) 24-hour battery carryover.
 - 3) Individual on-off-auto switches for each program.
 - 4) 365-day calendar with 20 programmable holidays.
 - 5) Choice of fail-safe operation for each program.
 - 6) System fault alarm.
- g. Ionization-Type Smoke Detectors:
 - 1) 24 V dc, nominal.
 - 2) Self-restoring.
 - 3) Plug-in arrangement
 - 4) Integral visual-indicating light.
 - 5) Sensitivity that can be tested and adjusted in place after installation.
 - 6) Integral addressable module.
 - 7) Remote controllability.
 - 8) Responsive to both visible and invisible products of combustion.
 - 9) Self-compensating for changes in environmental conditions.
 - 10) Located in supply[**and return**] air, shall stop fans when the presence of smoke is detected.
3. Fan Control, Interlocked: Fan to start automatically with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.
4. Fan Control, Timer: Timer starts and stops indirect-fired heating and ventilating unit and exhaust fan(s).
5. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.
6. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:
 - a. Minimum **[30]<Insert number>** percent outdoor air.
 - b. Outdoor-air quantity adjusted by potentiometer on control panel.
 - c. Outdoor-air quantity to maintain minimum building static pressure.
7. Temperature Control:
 - a. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
 - b. Operates gas valve to maintain space temperature with wall-mounted, field-wired sensor[**with temperature adjustment,][and unit-mounted control adjustment][and adjustment on remote-control panel]**.
 - c. Timer shall select remote setback thermostat to maintain space temperature at **[50 deg F (10 deg C)]<Insert temperature>**.
 - d. Burner Control, Stepped: Two or four steps of control using one or two burner sections in series.
 - e. Burner Control, Modulating: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual burner units.
8. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the

DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.

a. Hardwired Points:

- 1) Room temperature.
- 2) Discharge-air temperature.
- 3) Burner operating.

b. **[ASHRAE 135.1 (BACnet)][LonTalk][Modbus][Industry-accepted, open-protocol]<Insert type of interface>** communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

2.4 SOURCE QUALITY CONTROL

- A. **[AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.]**
- B. **[Fan Sound Performance Rating: Factory test and rate fan sound performance rating in accordance with AMCA 300/301.]**
- C. **[AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.]**
- D. **[Fan Aerodynamic Performance Rating: Factory test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210.]**
- E. **[Fan Energy Index: Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.]**
- F. **[AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.]**
- G. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

2.5 MATERIALS

- A. Steel:
 1. ASTM A36/A36M for carbon structural steel.
 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
 1. Manufacturer's standard grade for casing.
 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of indirect-fired heating and ventilating units.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF INDOOR, INDIRECT, GAS-FIRED HEATING AND VENTILATING UNITS

- A. Equipment Mounting:
 - 1. Install heating and ventilating units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Suspended Units: Suspend[**and brace**] units from structural-steel support frame using threaded steel rods and spring hangers. Coordinate sizes and locations of structural-steel support members with actual equipment provided. Comply with requirements for vibration isolation devices specified in [**Section 230548 "Vibration and Seismic Controls for HVAC."**][**Section 230548.13 "Vibration Controls for HVAC."**]
 - 1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install gas-fired units in accordance with NFPA 54.
- D. Install controls and equipment shipped by manufacturer for field installation with indirect, gas-fired heating and ventilating units.

3.3 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Gas Piping: Comply with requirements in [**Section 231123 "Facility Natural-Gas Piping."**][**Section 231126 "Facility Liquefied-Petroleum Gas Piping."**] Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless steel tubing flexible connectors

complying with ANSI LC 1/CSA 6.26 equipment connections.

- B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.
- C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

3.4 DUCTWORK CONNECTIONS

- A. Connect supply[**and return**] ducts to indirect, gas-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

3.5 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Inspect for visible damage to burner combustion chamber.
 - b. Inspect casing insulation for integrity, moisture content, and adhesion.
 - c. Verify that clearances have been provided for servicing.
 - d. Verify that controls are connected and operable.
 - e. Verify that filters are installed.
 - f. Purge gas line.
 - g. Inspect and adjust vibration isolators[**and seismic restraints**].

- h. Verify bearing lubrication.
- i. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
- j. Adjust fan belts to proper alignment and tension.

B. Start unit according to manufacturer's written instructions.

1. Complete startup sheets and attach copy with Contractor's startup report.
2. Inspect and record performance of interlocks and protective devices; verify sequences.
3. Operate unit for run-in period recommended by manufacturer.
4. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
5. Calibrate thermostats.
6. Adjust and inspect high-temperature limits.
7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
9. Measure and record airflow. Plot fan volumes on fan curve.
10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
 - a. High-limit heat.
 - b. Alarms.
11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
12. Verify drain-pan performance.
13. Verify outdoor-air damper operation.

3.8 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.9 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.



3.10 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner][Contractor]** will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
 - 1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties.
- D. Units will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.11 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION 23 73 00 00



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 73 00 00A - INDOOR, DIRECT-FIRED HEATING AND VENTILATING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Indoor, direct-fired heating and ventilating units.

1.2 ACTION SUBMITTALS

A. Product Data: For each indoor, direct, gas-fired heating and ventilating unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
 - e. Include fan-speed controllers.
6. Include filters with performance characteristics.
7. Include direct, gas-fired burners with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each indoor, direct, gas-fired heating and ventilating unit.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For vibration isolation[, **supports,**][**and seismic restraints**] indicated to



comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty.
- C. Seismic Qualification Data: Certificates for indoor, direct, gas-fired heating and ventilating units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Restraint of internal components.
- D. Startup service reports.
- E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For direct, gas-fired heating and ventilating units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: **[One]<Insert number>** set(s) for each unit.
 2. Gaskets: **[One]<Insert number>** set(s) for each access door.
 3. Fan Belts: **[One]<Insert number>** set(s) for each unit.

1.6 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of direct-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than **[one]<Insert number>** year(s) from date of Substantial Completion.
 2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than **[five]<Insert**



number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[, **supports**][**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Seismic Performance: Indoor, indirect gas-fired, heating and ventilating units are to withstand the effects of earthquake motions determined in accordance with [**ASCE/SEI 7**]**<Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: [**1.5**][**1.0**].
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Fan:
 - 1. Discharge Configuration: [**Horizontal**][**Vertical**].
 - 2. Airflow in CFM (L/s): **<Insert quantity>**.
 - 3. Total Static Pressure: **<Insert number> inches wg (Pa)**.
 - 4. External Static Pressure: **<Insert inches wg (kPa)>**.
 - 5. Maximum RPM: **<Insert number>**.
 - 6. Minimum Size: **<Insert inches (mm)>**.
 - 7. Altitude: **<Insert feet (m)>**.
- B. Fan Motor:
 - 1. Horsepower: **<Insert value>**.
 - 2. RPM: **<Insert value>**.
 - 3. Service Factor: **<Insert value>**.
 - 4. Speed: [**Single**][**Two**].

C. Single-Point Electrical Connection:

1. Volts: **[120][240][277][480]<Insert value> V.**
2. Phase: **[Single][Three].**
3. Hertz: 60.
4. Full-Load Amperes: **<Insert value> A.**
5. Minimum Circuit Ampacity: **<Insert value> A.**
6. Maximum Overcurrent Protection: **<Insert value> A.**

D. Direct-Fired Gas Burner:

1. Minimum Combustion Efficiency: **<Insert number> percent.**
2. Entering-Air Temperature: **<Insert deg F (deg C)>.**
3. Leaving-Air Temperature: **<Insert deg F (deg C)>.**
4. Airflow: **<Insert cfm (L/s)>.**
5. Gas Input: **<Insert MBh (kW)>.**
6. Burner Output: **<Insert MBh (kW)>.**
7. Number of Stages: **<Insert value>.**
8. Minimum Inlet Pressure: **<Insert inches wg (Pa)>.**
9. Maximum Inlet Pressure: **<Insert inches wg (Pa)>.**
10. Gas Piping Connection Size: **<Insert NPS (DN)>.**
11. Vent Diameter: **<Insert inches (mm)>.**

E. Filters:

1. Type: **<Insert type>.**
2. Face Dimensions, Each: **<Insert inches by inches (mm by mm)>.**
3. Depth: **<Insert inches (mm)>.**
4. Number of Filters, Wide by High: **<Insert number>.**
5. Access Location: **[Side]<Insert location>.**
6. Maximum or Rated Face Velocity: **<Insert fpm (m/s)>.**
7. Initial Resistance: **<Insert inches wg (Pa)>.**
8. Recommended Final Resistance: **<Insert inches wg (Pa)>.**
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating and Corresponding Average Arrestance: **[MERV 1][MERV 2][MERV 3][MERV 4]**, and corresponding average arrestance in accordance with ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 13]<Insert value>**, in accordance with ASHRAE 52.2.

2.3 INDOOR, DIRECT-FIRED HEATING AND VENTILATING UNITS**A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[AbsolutAire, Inc.]**
2. **[Advanced Climate Technologies, Inc.]**
3. **[Air Economy Corporation]**
4. **[Applied Air, a Mestek company]**
5. **[Banza; a brand of Specified Air Solutions]**
6. **[BessamAire, Inc.]**

7. [Cambridge Air Solutions]
8. [Cambridge Engineering, Inc]
9. [CaptiveAire Systems]
10. [Des Champs Technologies]
11. [E. K. Campbell Co.]
12. [Energy Jet U.S.]
13. [Engineered Air]
14. [Greenheck Fan Corporation]
15. [Hastings Industries]
16. [I.C.E. Manufacturing Ltd.; Industrial Commercial Equipment - I.C.E. (US), Inc.]
17. [Jackson & Church HVAC Global]
18. [KING]
19. [LC Systems]
20. [Modine Manufacturing Company]
21. [Nortek Air Solutions]
22. [Powrmatic, Inc.]
23. [Rapid Engineering, Inc.]
24. [REZNOR, a brand of Nortek Global HVAC]
25. [Sterling Gas]
26. [Sterling HVAC Products; a Mestek company]
27. [Temprite, a brand of Mestek]
28. [Titan Air]
29. [Trane Inc.]
30. [Weather-Rite, a brand of Specified Air Solutions]
31. <Insert manufacturer's name>

- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [AbsolutAire, Inc.]
2. [Advanced Climate Technologies, Inc.]
3. [Air Economy Corporation]
4. [Applied Air, a Mestek company]
5. [Banza; a brand of Specified Air Solutions]
6. [BessamAire, Inc.]
7. [Cambridge Air Solutions]
8. [Cambridge Engineering, Inc]
9. [CaptiveAire Systems]
10. [Des Champs Technologies]
11. [E. K. Campbell Co.]
12. [Energy Jet U.S.]
13. [Engineered Air]
14. [Greenheck Fan Corporation]
15. [Hastings Industries]
16. [I.C.E. Manufacturing Ltd.; Industrial Commercial Equipment - I.C.E. (US), Inc.]
17. [Jackson & Church HVAC Global]
18. [KING]
19. [LC Systems]
20. [Modine Manufacturing Company]
21. [Nortek Air Solutions]
22. [Powrmatic, Inc.]
23. [Rapid Engineering, Inc.]
24. [REZNOR, a brand of Nortek Global HVAC]
25. [Sterling Gas]
26. [Sterling HVAC Products; a Mestek company]
27. [Temprite, a brand of Mestek]

28. [Titan Air]
29. [Trane Inc.]
30. [Weather-Rite, a brand of Specified Air Solutions]
31. <Insert manufacturer's name>

C. Unit Casings:

1. General Fabrication Requirements for Casings:
 - a. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
 - b. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
 - c. Heating and Ventilating Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
2. Configuration: Horizontal unit with [top][horizontal][bottom] discharge for [floor-mounting][suspended] installation.
 - a. Discharge Section, Cowls: Trapezoidal cowls with horizontal louvers.
 - b. Discharge Section, Plenum: Plenum with [two][four] sides louvered.
 - c. Discharge Section, Down-Discharge: Down-discharge plenum insulated with 1-inch (25-mm), 1.5-lb/cu. ft. (24.0-kg/cu. m) fibrous glass.
3. Single-Wall Construction:
 - a. Material: [Galvanized-steel][or][aluminized-steel]<Insert material> with [manufacturer's standard finish]<Insert special coating>.
 - b. Floorplate: [Galvanized steel]<Insert material>, minimum [18 gauge (1.3 mm)]<Insert value> thick.
 - c. Insulation and Adhesive:
 - 1) Materials: [ASTM C1071, Type I or Type II glass-fiber blanket or board insulation, neoprene coated or foil faced]<Insert insulation type>.
 - 2) Insulation R-Value: Minimum <Insert value>.
 - 3) Insulation Thickness: [1 inch (25 mm)]<Insert dimension>.
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
 - 5) Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of [complete unit][burner and fan sections only].
 - a) Insulation Adhesive: Comply with ASTM C916, Type I.
 - b) Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.
4. Double-Wall Construction:
 - a. Outside Casing Wall: [Galvanized steel]<Insert material>, minimum [18 gauge (1.3 mm)]<Insert value> thick, with [manufacturer's standard finish]<Insert special coating>.
 - b. Inside Casing Wall:
 - 1) Inside Casing, Burner Section: [Galvanized steel]<Insert material>, solid, minimum [14-gauge (0.759-mm)]<Insert number> thick steel.
 - 2) Inside Casing, All Other Sections: [Galvanized steel]<Insert

material>[solid][perforated] steel.

- c. Floor Plate: **[Galvanized steel]<Insert material>**, minimum **[18 gauge (1.3 mm)]<Insert value>** thick.
 - d. Casing Insulation:
 - 1) Materials: **[Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071]<Insert insulation type>**.
 - 2) Casing Panel R-Value: Minimum **<Insert value>**.
 - 3) Insulation Thickness: **[1 inch (25 mm)]<Insert dimension>**.
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
 - e. Airstream Surfaces: Surfaces in contact with airstream are to comply with requirements in ASHRAE 62.1.
5. Inspection and Access Panels and Access Doors:
- a. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
 - b. Inspection and Access Panels:
 - 1) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement is to allow panels to be opened against air-pressure differential.
 - 2) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 3) Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
 - c. Access Doors:
 - 1) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
 - 2) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 3) Fabricate windows in **[fan section]** doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
 - 4) Size: At least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** wide by full height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>**.
 - d. Locations and Applications:
 - 1) Fan Section: **[Inspection and access panels][Doors][Doors and inspection and access panels]**.
 - 2) Access Section: Doors.
 - 3) Gas-Fired Burner Section: **[Inspection and access panels][Doors]**.
 - 4) Damper Section: **[Inspection and access panels][Doors]**.
 - 5) Filter Section: **[Inspection and access panels][Doors]** large enough to allow periodic removal and installation of filters.
 - 6) Mixing Section: Doors.
 - e. Service Light: 100-W vaporproof fixture with switched junction box located **[outside][inside]** adjacent to door.
 - 1) Locations: **[Each section accessed with door][Fan section]<Insert location>**.

D. Fan, Drive, And Motor:

1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
2. Fans: Centrifugal, rated in accordance with AMCA 210; galvanized steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway.
 - b. Shaft Bearings: Heavy-duty[, **self-aligning, permanently lubricated ball bearings**][, **pillow-block bearings**] with an [L50]<Insert bearing life rating> rated life of [100,000]<Insert number> hours in accordance with ABMA 9.
 - c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - d. Mounting: For internal vibration isolation[**and seismic control**]. Factory-mount fans with manufacturer's standard[**restrained**] vibration isolation mounting devices having a minimum static deflection of [1 inch (25 mm)]<Insert dimension>.
 - e. Shaft Lubrication Lines: Extended to a location outside the casing.
 - f. Flexible Connector: Factory fabricated with a fabric strip minimum **3-1/2 inches (89 mm)** wide, attached to two strips of minimum **2-3/4-inch- (70-mm-)** wide by **0.028-inch- (0.7-mm-)** thick, galvanized-steel sheet.
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives are to comply with UL 181, Class 1.
3. Drive: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with [1.5][1.25] service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards"; [0.146-inch- (2.7-mm-)]<Insert dimension> thick, [3/4-inch (20-mm)]<Insert dimension> diamond-mesh wire screen, welded to steel angle frame; prime coated.
4. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Maximum sizes as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure Type: [Open, dripproof][Totally enclosed, fan cooled]<Insert type>.
 - d. Enclosure Materials: [Cast iron]<Insert material>.
 - e. Motor Bearings: <Insert requirements>.
 - f. Unusual Service Conditions:
 - 1) Ambient Temperature: <Insert deg C>.
 - 2) Altitude: <Insert feet (m)> above sea level.
 - 3) High humidity.
 - 4) <Insert conditions>.
 - g. Efficiency: Premium efficient as defined in NEMA MG 1.

- h. NEMA Design: **<Insert designation>**.
- i. Motor Pulleys: Adjustable pitch for use with **[5]<Insert number>**-hp motors and smaller; fixed pitch for use with motors larger than **[5]<Insert number>** hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.

E. Air Filtration:

- 1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- 2. Panel Filters:
 - a. Description: **[Flat, non-pleated][Pleated]** factory-fabricated, self-supported, disposable air filters with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
 - d. Filter-Media Frame: **[Beverage board]<Insert material>** with perforated metal retainer, or metal grid, on outlet side.
- 3. Cleanable Filters:
 - a. Cleanable metal mesh.
- 4. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
- 5. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- 6. Side-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. **[Galvanized-steel]<Insert material>** track.
 - 1) Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

F. Dampers:

- 1. Comply with requirements in Section 230923.12 "Control Dampers."
- 2. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, **[galvanized-steel]<Insert material>** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **[opposed][parallel]**-blade arrangement with **[zinc-plated]** steel operating rods rotating in **[sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel]<Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate is not to exceed **[4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa), leakage Class 1]<Insert requirement>**, **tested, rated, and labeled in accordance with AMCA 511**.
- 3. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
- 4. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator is to have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - c. Operator Motors:

- 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
- d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
- e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
- f. Size dampers for running torque calculated as follows:
- 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft. (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
- g. Coupling: V-bolt and V-shaped, toothed cradle.
- h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
- i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
- j. Power Requirements (Two-Position Spring Return): **[24 V dc][120 V ac][230 V ac]**.
- k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
- l. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
- m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.
- n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.

G. Direct-Fired Gas Burner:

1. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54
2. CSA Approval: Designed and certified by and bearing label of CSA.
3. Burners: **[Aluminized steel with stainless steel inserts][Stainless steel]**.
 - a. Rated Minimum Turndown Ratio: **[30 to 1]<Insert ratio>**.
 - b. Fuel: **[Natural][Propane]** gas.
 - c. Ignition: Electronically controlled electric spark with flame sensor.
 - d. Gas Control Valve: **[Single stage][Two stage][Modulating]**.
 - e. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, **[hydraulic][electronic]**-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - f. High-Altitude Model Kit: For Project elevations more than **2000 feet (610 m)** above sea

level.

4. Heat-Exchanger and Drain Pan: Stainless steel.
5. Safety Controls:
 - a. Gas Manifold: Safety switches and controls complying with ANSI standards **[and][FM Global]<Insert insurer>**.
 - b. Vent Flow Verification: **[Differential pressure switch to verify open vent][Flame rollout switch]**.
 - c. High Limit: Thermal switch or fuse to stop burner.
 - d. Purge-period timer is to automatically delay burner ignition and bypass low-limit control.
 - e. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
 - f. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - g. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
 - h. Control Transformer: 24 V ac.

H. Unit Control Panel:

1. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
2. Control Panel: **[Surface-mounted][Recessed, with trim ring,]** remote panel, with engraved plastic cover and the following lights and switches:
 - a. **[On-off][On-off-auto]** fan switch.
 - b. Heat-vent-off switch.
 - c. Supply-fan operation indicating light.
 - d. Heating operation indicating light.
 - e. Thermostat.
 - f. Damper position potentiometer.
 - g. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
 - h. Safety-lockout indicating light.
 - i. Enclosure: NEMA 250, **[Type 1][Type 3R][Type 4][Explosion proof]**.

I. Controls:

1. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.
2. Control Devices:
 - a. Remote Thermostat: Adjustable room thermostat with temperature readout.
 - b. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
 - c. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - d. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than **75 deg F (24 deg C)** above normal maximum operating temperature.
 - e. Timers, Seven Day:
 - 1) Programming-switch timer with synchronous-timing motor and seven-day dial.
 - 2) Continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover.
 - 3) Multiple-switch trippers.
 - 4) Minimum of two and maximum of eight signals per day with two normally open and

two normally closed output contacts.

- f. Timers, Solid State:
 - 1) Programmable time control with four separate programs.
 - 2) 24-hour battery carryover.
 - 3) Individual on-off-auto switches for each program.
 - 4) 365-day calendar with 20 programmable holidays.
 - 5) Choice of fail-safe operation for each program.
 - 6) System fault alarm.
- g. Ionization-Type Smoke Detectors:
 - 1) 24 V dc, nominal.
 - 2) Self-restoring.
 - 3) Plug-in arrangement
 - 4) Integral visual-indicating light.
 - 5) Sensitivity that can be tested and adjusted in place after installation.
 - 6) Integral addressable module.
 - 7) Remote controllability.
 - 8) Responsive to both visible and invisible products of combustion.
 - 9) Self-compensating for changes in environmental conditions.
 - 10) Located in supply[**and return**] air, detectors are to stop fans when the presence of smoke is detected.
- 3. Fan Control, Interlocked: Fan to start automatically with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.
- 4. Fan Control, Timer: Timer starts and stops direct gas-fired heating and ventilating unit and exhaust fan(s).
- 5. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper is to open when supply fan starts, and close when fan stops.
- 6. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers are to modulate to supply minimum outdoor air as follows:
 - a. Minimum **[30]<Insert number>** percent outdoor air.
 - b. Outdoor-air quantity adjusted by potentiometer on control panel.
 - c. Outdoor-air quantity to maintain minimum building static pressure.
- 7. Temperature Control:
 - a. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
 - b. Timer is to select remote setback thermostat to maintain space temperature at **[50 deg F (10 deg C)]<Insert temperature>**.
 - c. Burner Control: Two or four steps of control using one or two burner sections in series.
- 8. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.
 - a. Hardwired Points:
 - 1) Room temperature.
 - 2) Discharge-air temperature.
 - 3) Burner operating.

- b. **[ASHRAE 135.1 (BACnet)][LonTalk][Modbus][Industry-accepted, open-protocol]<Insert type of interface>** communication interface with the DDC system for HVAC is to enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel are to be available through the DDC system for HVAC.

2.4 SOURCE QUALITY CONTROL

- A. **[AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.]**
- B. **[Fan Sound Performance Rating: Factory test and rate fan sound performance rating in accordance with AMCA 300/301.]**
- C. **[AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.]**
- D. **[Fan Aerodynamic Performance Rating: Factory test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210.]**
- E. **[Fan Energy Index: Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.]**
- F. **[AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.]**
- G. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

2.5 MATERIALS

- A. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
 - 1. Manufacturer's standard grade for casing.
 - 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of indirect-fired heating and ventilating units.

- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting:
 - 1. Install heating and ventilating units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Suspended Units: Suspend[**and brace**] units from structural-steel support frame using threaded steel rods and spring hangers. Coordinate sizes and locations of structural-steel support members with actual equipment provided. Comply with requirements for vibration isolation devices specified in [Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]
- C. Install gas-fired units in accordance with NFPA 54, "National Fuel Gas Code."
- D. Install controls and equipment shipped by manufacturer for field installation with direct, gas-fired heating and ventilating units.
- E. Install seismic restraints in accordance with manufacturer's written instructions.

3.3 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Gas Piping: Comply with requirements in [Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping."] Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.
- B. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

3.4 DUCTWORK CONNECTIONS

- A. Connect supply[**and return**] ducts to direct-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions and perform the following:
 - a. Inspect for visible damage to burner combustion chamber.
 - b. Inspect casing insulation for integrity, moisture content, and adhesion.
 - c. Verify that clearances have been provided for servicing.
 - d. Verify that controls are connected and operable.
 - e. Verify that filters are installed.
 - f. Purge gas line.
 - g. Inspect and adjust vibration isolators[**and seismic restraints**].
 - h. Verify bearing lubrication.
 - i. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - j. Adjust fan belts to proper alignment and tension.
 - k. Start unit in accordance with manufacturer's written instructions.
 - 2. Complete startup sheets and attach copy with Contractor's startup report.
 - 3. Inspect and record performance of interlocks and protective devices; verify sequences.
 - 4. Operate unit for run-in period recommended by manufacturer.
 - 5. Perform the following operations for both minimum and maximum firing and adjust burner for

peak efficiency:

- a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
6. Calibrate thermostats.
 7. Adjust and inspect high-temperature limits.
 8. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
 9. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 10. Measure and record airflow. Plot fan volumes on fan curve.
 11. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
 - a. High-limit heat.
 - b. Alarms.
 12. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
 13. Verify drain-pan performance.
 14. Verify outdoor-air damper operation.

3.8 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.9 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner][Contractor]** will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].



1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties.

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.11 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION 23 73 00 00A



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 73 13 00 - INDOOR, BASIC AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Indoor, basic air-handling units.
2. Unit casings.
3. Fan, drive, and motor section.
4. Coil section.
5. Air filtration section.
6. Dampers.

1.2 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each type and configuration of indoor, basic, air-handling unit.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of indoor, basic air-handling units, as well as procedures and

diagrams.

4. Include diagrams for power, signal, and control wiring.

- D. Delegated Design Submittal: For vibration isolation[, **supports**,][**and seismic restraints**] indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators[, **supports**,][**and seismic restraints**] and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Seismic Qualification Data: Certificates for indoor, basic air-handling units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Restraint of internal components.
- C. Source quality-control reports.
- D. Startup service reports.
- E. Field quality-control reports.
- F. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: [**One**]<Insert number> set(s) for each air-handling unit.
 2. Gaskets: [**One**]<Insert number> set(s) for each access door.
 3. Fan Belts: [**One**]<Insert number> set(s) for each air-handling unit fan.

1.6 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of indoor, basic, air-handling units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Manufacturer's standard, but not less than **[one]<Insert number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Structural Performance: Casing panels are to be self-supporting and capable of withstanding positive/negative **[4-inch wg (996 Pa)]<Insert value>** of internal static pressure, without exceeding a midpoint deflection of **[0.005 inches/inch (0.005 mm/mm)]<Insert value>** of panel span.
- G. Seismic Performance: Air-handling units are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Supply Fan:
 - 1. Type: **[DWDI, forward-curved centrifugal fan][SWSI, airfoil unhooded centrifugal plenum fan]<Insert fan type>**.
 - 2. Class: AMCA 99, Section 14, **[Class I][Class II]**.
 - 3. Drive: **[V-belt][Direct]**.

4. Number of Fan Wheels: **[One]<Insert number>**.
5. Fan Diameter: **<Insert number> inches (mm)**.
6. Airflow: **<Insert number> cfm (L/s)**.
7. Total Static Pressure: **<Insert number> inches wg (kPa)**.
8. External Static Pressure: **<Insert number> inches wg (kPa)**.
9. Speed: **<Insert rpm>**.
10. Maximum Outlet Velocity: **<Insert number> fpm (m/s)**.
11. Motor:
 - a. Size: **<Insert horsepower>**.
 - b. Speed: **<Insert rpm>**.
 - c. Volts: **[208][230][460]<Insert value> V**.
 - d. Phase: **[Three]<Insert number>**.
 - e. Hertz: **[60]<Insert number> Hz**.
 - f. Full-Load Amperes: **<Insert value> A**.
 - g. Minimum Circuit Ampacity: **<Insert value> A**.
 - h. Maximum Overcurrent Protection: **<Insert amperage> A**.
12. Fan Discharge Sound Power, dB:
 - a. 1st Octave: **<Insert value>**.
 - b. 2nd Octave: **<Insert value>**.
 - c. 3rd Octave: **<Insert value>**.
 - d. 4th Octave: **<Insert value>**.
 - e. 5th Octave: **<Insert value>**.
 - f. 6th Octave: **<Insert value>**.
 - g. 7th Octave: **<Insert value>**.
 - h. 8th Octave: **<Insert value>**.

B. Return Fan:

1. Type: **[DWDI, forward-curved centrifugal fan][SWSI, airfoil unhooded centrifugal plenum fan]<Insert fan type>**.
2. Class: **AMCA 99, Section 14, [Class I][Class II]**.
3. Drive: **[V-belt][Direct]**.
4. Number of Fan Wheels: **[One]<Insert number>**.
5. Fan Diameter: **<Insert number> inches (mm)**.
6. Airflow: **<Insert number> cfm (L/s)**.
7. Total Static Pressure: **<Insert number> inches wg (kPa)**.
8. External Static Pressure: **<Insert number> inches wg (kPa)**.
9. Speed: **<Insert rpm>**.
10. Maximum Outlet Velocity: **<Insert number> fpm (m/s)**.
11. Motor:
 - a. Size: **<Insert value> hp**.
 - b. Speed: **<Insert rpm>**.
 - c. Volts: **[208][230]<Insert value> V**.
 - d. Phase: **[Three]<Insert number>**.
 - e. Hertz: **[60]<Insert number> Hz**.
 - f. Full-Load Amperes: **<Insert value> A**.
 - g. Minimum Circuit Ampacity: **<Insert value> A**.
 - h. Maximum Overcurrent Protection: **<Insert amperage> A**.
12. Fan Inlet Sound Power, dB:

- a. 1st Octave: **<Insert value>**.
- b. 2nd Octave: **<Insert value>**.
- c. 3rd Octave: **<Insert value>**.
- d. 4th Octave: **<Insert value>**.
- e. 5th Octave: **<Insert value>**.
- f. 6th Octave: **<Insert value>**.
- g. 7th Octave: **<Insert value>**.
- h. 8th Octave: **<Insert value>**.

C. Preheat Coil:

1. Heat-Transfer Rate: **<Insert number> Btu/h (kW)**.
2. Entering-Air Temperature: **<Insert number> deg F (deg C)**.
3. Leaving-Air Temperature: **<Insert number> deg F (deg C)**.
4. Face Area: **<Insert number> sq. ft. (sq. m)**.
5. Maximum Face Velocity: **<Insert number> fpm (m/s)**.
6. Maximum Air-Side, Static-Pressure Drop: **<Insert number> inches wg (Pa)**.
7. Fin Spacing: Maximum **<Insert number> fins per inch (per mm)**.
8. Minimum Number of Rows: **<Insert number>**.
9. Water:
 - a. Water Flow: **<Insert number> gpm (L/s)**.
 - b. Maximum Water Pressure Drop: **<Insert number> feet of head (kPa)**.
 - c. Entering-Water Temperature: **<Insert number> deg F (deg C)**.
 - d. Leaving-Water Temperature: **<Insert number> deg F (deg C)**.
 - e. Tube Velocity: **<Insert number> fpm (L/s)**.
10. Steam:
 - a. Steam Flow: **<Insert number> lb/h (g/s)**.
 - b. Inlet Steam Pressure: **<Insert number> psig (kPa)**.
 - c. Outer-Tube Diameter: **<Insert number> inches (mm)**.

D. Heating Coil:

1. Heat-Transfer Rate: **<Insert number> Btu/h (kW)**.
2. Entering-Air Temperature: **<Insert number> deg F (deg C)**.
3. Leaving-Air Temperature: **<Insert number> deg F (deg C)**.
4. Face Area: **<Insert number> sq. ft. (sq. m)**.
5. Maximum Face Velocity: **<Insert number> fpm (m/s)**.
6. Maximum Air-Side, Static-Pressure Drop: **<Insert number> inches wg (Pa)**.
7. Number of Rows: **<Insert number>**.
8. Fin Spacing: Maximum **<Insert number> fins per inch (per mm)**.
9. Water:
 - a. Water Flow: **<Insert number> gpm (L/s)**.
 - b. Maximum Water Pressure Drop: **<Insert number> feet of head (kPa)**.
 - c. Entering-Water Temperature: **<Insert number> deg F (deg C)**.
 - d. Leaving-Water Temperature: **<Insert number> deg F (deg C)**.
 - e. Tube Velocity: **<Insert number> fpm (L/s)**.
10. Steam:
 - a. Steam Flow: **<Insert number> lb/h (g/s)**.
 - b. Inlet Steam Pressure: **<Insert number> psig (kPa)**.

E. Electric Heating Coil:

1. Heat-Transfer Rate: **<Insert number> Btu/h (kW).**
2. Input: **<Insert kilowatts>.**
3. Volts: **[120][208][230]<Insert value> V.**
4. Phase: **[Single][Three].**
5. Full-Load Amperes: **<Insert value> A.**
6. Number of Steps: **<Insert number>.**

F. Cooling Coil:

1. Sensible Heat-Transfer Rate: **<Insert number> Btu/h (kW).**
2. Total Heat-Transfer Rate: **<Insert number> Btu/h (kW).**
3. Entering-Air, Dry-Bulb Temperature: **<Insert number> deg F (deg C).**
4. Entering-Air, Wet-Bulb Temperature: **<Insert number> deg F (deg C).**
5. Leaving-Air, Dry-Bulb Temperature: **<Insert number> deg F (deg C).**
6. Leaving-Air, Wet-Bulb Temperature: **<Insert number> deg F (deg C).**
7. Face Area: **<Insert number> sq. ft. (sq. m).**
8. Maximum Face Velocity: **<Insert number> fpm (m/s).**
9. Maximum Air-Side, Static-Pressure Drop: **<Insert number> inches wg (Pa).**
10. Number of Rows: **<Insert number>.**
11. Fin Spacing: Maximum **<Insert number> fins per inch (per mm).**
12. Water:
 - a. Water Flow: **<Insert number> gpm (L/s).**
 - b. Maximum Water Pressure Drop: **<Insert number> feet of head (kPa).**
 - c. Entering-Water Temperature: **<Insert number> deg F (deg C).**
 - d. Leaving-Water Temperature: **<Insert number> deg F (deg C).**
 - e. Tube Velocity: **<Insert number> fpm (L/s).**
13. Refrigerant:
 - a. Refrigerant Type: **<Insert refrigerant type>.**

G. Filters:

1. Type: **<Insert type>.**
2. Face Dimensions, Each: **<Insert number> inches by inches (mm by mm).**
3. Depth: **<Insert number> inches (mm).**
4. Number of Filters in Filter Bank: **<Insert number> wide by <Insert number> high.**
5. Access Location: **[Side]<Insert location>.**
6. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s).**
7. Initial Resistance: **<Insert number> inches wg (Pa).**
8. Recommended Final Resistance: **<Insert number> inches wg (Pa).**
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating and Corresponding Average Arrestance: **[MERV 1][MERV 2][MERV 3][MERV 4]**, and corresponding average arrestance in accordance with ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 13]<Insert value>**, in accordance with ASHRAE 52.2.

2.3 INDOOR, BASIC AIR-HANDLING UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Airtherm; a Mestek company]**
2. **[Buffalo Air Handling]**
3. **[Carrier Global Corporation]**
4. **[Daikin Applied]**
5. **[Dunham-Bush, Inc]**
6. **[ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]**
7. **[Titus; brand of Johnson Controls International plc, Global Products]**
8. **[Trane]**
9. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
10. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Airtherm; a Mestek company]**
2. **[Buffalo Air Handling]**
3. **[Carrier Global Corporation]**
4. **[Daikin Applied]**
5. **[Dunham-Bush, Inc]**
6. **[ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]**
7. **[Titus; brand of Johnson Controls International plc, Global Products]**
8. **[Trane]**
9. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
10. **<Insert manufacturer's name>**

- C. Unit Casings:

1. General Fabrication Requirements for Casings:

- a. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
- b. Joints: Sheet metal screws or pop rivets.
- c. Sealing: Seal all joints with water-resistant sealant. Hermetically seal at each corner and around entire perimeter.
- d. Base Rail:
 - 1) Material: **[Galvanized steel]<Insert material>**.
 - 2) Height: **[4 inches (150 mm)]<Insert dimension>**.

2. Single-Wall Construction:

- a. Material: **[Galvanized steel]<Insert material>** with **[manufacturer's standard finish]<Insert special coating>**.
- b. Floor Plate: **[Galvanized steel]<Insert material>**, **[treadplate,]minimum [18 gauge (1.3 mm)]<Insert value>** thick.
- c. Insulation and Adhesive:
 - 1) Materials: **[ASTM C1071, Type I or Type II glass-fiber blanket or board insulation, neoprene coated or foil faced]<Insert insulation type>**.

- 2) Insulation R-Value: Minimum **<Insert value>**.
 - 3) Insulation Thickness: **[1 inch (25 mm)]<Insert dimension>**.
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
 - 5) Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface **[of all complete unit][, downstream from, and including, the cooling coil section]**.
 - a) Liner Adhesive: Comply with ASTM C916, Type I.
 - b) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, or mechanical attachment, to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
3. Double-Wall Construction:
- a. Outside Casing Wall: **[Galvanized steel]<Insert material>**, minimum **[18 gauge (1.3 mm)]<Insert value>** thick, with **[manufacturer's standard finish]<Insert special coating>**.
 - b. Inside Casing Wall: **[G90 (Z275) galvanized steel]<Insert material>**, **[solid][perforated]**, minimum **[18 gauge (1.3 mm)]<Insert value>** thick.
 - c. Floor Plate: **[G90 (Z275) galvanized steel]<Insert material>**, **[treadplate]**, minimum **[18 gauge (1.3 mm)]<Insert value>** thick.
 - d. Casing Insulation:
 - 1) Materials: **[Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071][or][injected polyurethane foam insulation]**.
 - 2) Casing Panel R-Value: Minimum **<Insert value>**.
 - 3) Insulation Thickness: **[1 inch (25 mm)]<Insert dimension>**.
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
4. Airstream Surfaces: Surfaces in contact with airstream are to comply with requirements in ASHRAE 62.1.
5. Static-Pressure Classifications:
- a. For Unit Sections Upstream of Fans: Minus **[2-inch wg (500 Pa)][3-inch wg (750 Pa)]<Insert value>**.
 - b. For Unit Sections Downstream and Including Fans: **[2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert value>**.
6. Panels and Doors:
- a. Panels:
 - 1) Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - 2) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement is to allow panels to be opened against airflow.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. At least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** wide by full height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>**.
 - b. Doors:

- 1) Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - 3) Gasket: Neoprene, applied around entire perimeters of frame.
 - 4) Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least **[18 inches (450 mm)]<Insert dimension>** wide by full height of unit casing up to a maximum height of **[60 inches (1500 mm)]<Insert dimension>**.
- c. Locations and Applications:
- 1) Fan Section: **[Doors][Panels]**.
 - 2) Coil Section: Panels.
 - 3) Access Section: **[Doors][Panels]**.
 - 4) Access Sections Immediately Upstream and Downstream of Coil Sections: **[Doors][Panels]**.
 - 5) Damper Section: **[Doors][Panels]**.
 - 6) Filter Section: **[Doors][Panels]** large enough to allow periodic removal and installation of filters.
 - 7) Mixing Section: **[Doors][Panels]**.
7. Condensate Drain Pans:
- a. Location: Each type of cooling coil.
 - b. Construction:
 - 1) Single-wall, **[galvanized-steel or noncorrosive polymer][stainless steel]** sheet.
 - c. Drain Connection:
 - 1) Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **[one end][both ends]** of pan.
 - 2) Minimum Connection Size: **[NPS 1 (DN 25)][NPS 2 (DN 50)]<Insert pipe size>**.
 - d. Slope: Minimum **[0.125 in./ft. (10 mm/mm)]<Insert dimension>** slope, **[to comply with ASHRAE 62.1,]** in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers, and to direct water toward drain connection.
 - e. Length: Extend drain pan downstream from leaving face **[for distance to comply with ASHRAE 62.1]<Insert distance>**.
 - f. Width: Entire width of water producing device.
 - g. Depth: A minimum of **[2 inches (50 mm)]<Insert dimension>** deep.
- D. Fan, Drive, and Motor Section:
1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
 2. Fans: Centrifugal, galvanized steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway.

- b. Shaft Bearings:
 - 1) Heavy-duty, self-aligning, pillow-block type with an **[L-50]<Insert bearing life rating>** rated life of minimum **[100,000]<Insert number>** hours in accordance with ABMA 9.
 - c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - 1) Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 - d. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
 - e. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; **[steel][aluminum]** hub swaged to backplate and fastened to shaft with setscrews.
 - f. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
 - g. Mounting: For internal vibration isolation[**and seismic control**]. Factory-mount fans with manufacturer's standard[**restrained**] vibration isolation mounting devices having a minimum static deflection of **[1 inch (25 mm)]<Insert dimension>**.
 - h. Shaft Lubrication Lines: Extended to a location outside the casing.
 - i. Flexible Connector: Factory fabricated with a fabric strip minimum **3-1/2 inches (89 mm)** wide, attached to two strips of minimum **2-3/4-inch- (70-mm-)** wide by **0.028-inch- (0.7-mm-)** thick, galvanized-steel sheet.
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives are to comply with UL 181, Class 1.
- 3. Drive, Direct: Factory-mounted, direct drive.
 - 4. Drive, Belt: Factory-mounted, V-belt drive, with adjustable alignment and belt tensioning, and with **[1.5][1.25]** service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards"; **[0.146-inch- (2.7-mm-)]<Insert dimension>** thick, **[3/4-inch (20-mm)]<Insert dimension>** diamond-mesh wire screen, welded to steel angle frame; prime coated.
 - 5. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 - d. Enclosure Materials: **[Cast iron]<Insert material>**.
 - e. Motor Bearings: **<Insert requirements>**.
 - f. Unusual Service Conditions:

- 1) Ambient Temperature: **<Insert deg C>**.
 - 2) Altitude: **<Insert feet (m)>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
 - g. Efficiency: Premium efficient as defined in NEMA MG 1.
 - h. NEMA Design: **<Insert designation>**.
 - i. Motor Pulleys: Adjustable pitch for use with **[5]<Insert number>**-hp motors and smaller; fixed pitch for use with motors larger than **[5]<Insert number>** hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - j. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
6. Comply with Section 262923 "Variable-Frequency Motor Controllers."
7. Variable-Frequency Motor Controller: Serving **[each fan individually][all fans combined]** in fan array.
- a. Manufactured Units: Pulse-width modulated; **[constant torque][and][variable torque]<Insert application>** for **[Design A and Design B][inverter-duty]** motors.
 - b. Output Rating: Three phase; 10 to **[60 Hz, with voltage proportional to frequency throughout voltage range][66 Hz, with torque constant as speed changes]**; maximum voltage equals input voltage.
 - c. Unit Operating Requirements:
 - 1) Internal Adjustability:
 - a) Minimum Speed: 5 to 25 percent of maximum rpm.
 - b) Maximum Speed: 80 to 100 percent of maximum rpm.
 - c) Acceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - d) Deceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - e) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - 2) Self-Protection and Reliability Features:
 - a) Surge suppression.
 - b) Loss of input signal protection.
 - c) Under- and overvoltage trips.
 - d) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - e) Critical frequency rejection.
 - f) Loss-of-phase protection.
 - g) Reverse-phase protection.
 - h) Motor-temperature fault.
 - 3) Bidirectional autospeed search.
 - 4) Torque boost.
 - 5) Motor temperature compensation at slow speeds.
 - a) Panel-mounted operator station.
 - b) Historical logging information and displays.
 - c) Digital indicating devices.
 - 6) Control Signal Interface: Electric.
 - 7) Proportional Integral Directive (PID) control interface.
 - 8) DDC system for HVAC Protocols for Network Communications: **[ASHRAE 135]<Insert protocol type>**.

d. Line Conditioning:

- 1) Input line conditioning.
- 2) Output filtering.
- 3) EMI/RFI filtering.

e. <Insert features>.

E. Coil Section:

1. General Requirements for Coil Section:

- a. Comply with AHRI 410.
- b. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
- c. Coils are not to act as structural component of unit.

2. Preheat Coils:

a. Electrical Coils: Comply with UL 1995.

- 1) Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
- 2) Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
- 3) Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
- 4) Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
- 5) Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - a) **[Magnetic][Mercury]** contactor.
 - b) Solid-state, stepless pulse controller.
 - c) Toggle switches, one per step.
 - d) Step controller.
 - e) Time-delay relay.
 - f) Pilot lights, one per step.
 - g) Airflow proving switch.

b. Hot-Water Coils: **[Continuous circuit][Self-draining][Cleanable]**.

- 1) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
- 2) Tube Material: **[Copper]<Insert material>**.
- 3) Fin Type: Plate.
- 4) Fin Material: **[Aluminum][Copper]<Insert material>**.
- 5) Fin Thickness: **<Insert number> inches (mm)**.
- 6) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
- 7) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.
 - b) Seamless copper tube with brazed joints, prime coated.

- c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 8) Frames: Channel frame, minimum **0.052-inch- (1.3-mm-)** thick galvanized steel.
 - 9) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>.**
 - 10) Coating: **[None][Corrosion-resistant coating].**
 - c. Steam Coils: **[Distributed][Single tube].**
 - 1) Steam Outer-Tube Diameter: **<Insert number> inches (mm).**
 - 2) Piping Connections: **[Threaded][Flanged], [same end][opposite ends]** of coil.
 - 3) Tube Material: **[Copper]<Insert material>.**
 - 4) Fin Type: Plate.
 - 5) Fin Material: **[Aluminum][Copper]<Insert material>.**
 - 6) Fin Thickness: **<Insert number> inches (mm).**
 - 7) Fin and Tube Joint: **[Mechanical bond][Silver brazed].**
 - 8) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit].**
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 9) Frames: Channel frame, minimum **0.052-inch- (1.3-mm-)** thick galvanized steel.
 - 10) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>.**
 - 11) Coating: **[None][Corrosion-resistant coating].**
3. Heating Coils:
- a. Electrical Coils: Comply with UL 1995.
 - 1) Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
 - 2) Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - 3) Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 - 4) Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 - 5) Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - a) **[Magnetic][Mercury]** contactor.
 - b) Solid-state, stepless pulse controller.
 - c) Toggle switches, one per step.
 - d) Step controller.
 - e) Time-delay relay.
 - f) Pilot lights, one per step.
 - g) Airflow proving switch.
 - b. Hot-Water Coils: **[Continuous circuit][Self-draining][Cleaning].**

- 1) Piping Connections: [Threaded][Flanged], [same end][opposite ends] of coil.
 - 2) Tube Material: [Copper]<Insert material>.
 - 3) Fin Type: Plate.
 - 4) Fin Material: [Aluminum][Copper]<Insert material>.
 - 5) Fin Thickness: <Insert number> inches (mm).
 - 6) Fin and Tube Joint: [Mechanical bond][Silver brazed].
 - 7) Headers:
 - a) Cast iron with[cleaning plugs and] drain and air vent tappings[extended to exterior of unit].
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 8) Frames: Channel frame, minimum **0.052-inch- (1.3-mm-)** thick galvanized steel.
 - 9) Coil Working-Pressure Ratings: [200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>.
 - 10) Coating: [None][Corrosion-resistant coating].
- c. Steam Coils: [Distributed][Single tube].
- 1) Steam Outer-Tube Diameter: <Insert number> inches (mm).
 - 2) Piping Connections: [Threaded][Flanged], [same end][opposite ends] of coil.
 - 3) Tube Material: [Copper]<Insert material>.
 - 4) Fin Type: Plate.
 - 5) Fin Material: [Aluminum][Copper]<Insert material>.
 - 6) Fin Thickness: <Insert number> inches (mm).
 - 7) Fin and Tube Joint: [Mechanical bond][Silver brazed].
 - 8) Headers:
 - a) Cast iron with[cleaning plugs and] drain and air vent tappings[extended to exterior of unit].
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 9) Frames: Channel frame, minimum **0.052-inch- (1.3-mm-)** thick galvanized steel.
 - 10) Coil Working-Pressure Ratings: [200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>.
 - 11) Coating: [None][Corrosion-resistant coating].
4. Cooling Coils:
- a. Chilled-Water Coil: [Continuous circuit][Self-draining][Cleanable].
- 1) Piping Connections: [Threaded][Flanged], [same end][opposite ends] of coil.
 - 2) Tube Material: [Copper]<Insert material>.
 - 3) Tube Thickness: <Insert number> inches (mm).
 - 4) Fin Type: Plate.
 - 5) Fin Material: [Aluminum][Copper]<Insert material>.
 - 6) Fin Thickness: <Insert number> inches (mm).
 - 7) Fin and Tube Joint: [Mechanical bond][Silver brazed].
 - 8) Headers:
 - a) Cast iron with[cleaning plugs and] drain and air vent tappings[extended to

exterior of unit].

- b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
- 9) Frames: Channel frame, minimum **0.052-inch- (1.3-mm-)** thick galvanized steel.
 - 10) Coatings: **[None][Corrosion-resistant coating]**.
 - 11) Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.

b. Refrigerant Coil:

- 1) Tubes: **[Copper]<Insert material>**.
- 2) Fins:
 - a) Material: **[Aluminum]<Insert material>**.
- 3) Fin and Tube Joints: Mechanical bond.
- 4) Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
- 5) Frames: **[Galvanized steel]<Insert material frame>**.
- 6) Coatings: **[None][Corrosion-resistant coating]**.
- 7) Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - a) Working Pressure: Minimum **300 psig (2070 kPa)**.

F. Air Filtration Section:

- 1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- 2. Panel Filters:
 - a. Description: **[Flat, non-pleated][Pleated]** factory-fabricated, self-supported disposable air filters with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
 - d. Filter-Media Frame: **[High wet-strength beverage board]<Insert material>** with perforated metal retainer, or metal grid, on outlet side.
- 3. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
- 4. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- 5. Side-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. **[Galvanized steel]<Insert material>** track.
 - 1) Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

G. Dampers:

1. Comply with requirements in Section 230923.12 "Control Dampers."
2. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, **[galvanized-steel]<Insert material>** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **[opposed][parallel]**-blade arrangement with **[zinc-plated]** steel operating rods rotating in **[sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel]<Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate is not to exceed **4 cfm/sq. ft. (20 L/s per sq. m)** at **1-inch wg (250 Pa)** and **8 cfm/sq. ft. (40 L/s per sq. m)** at **4-inch wg (1.0 MPa)**, **tested, rated, and labeled in accordance with AMCA 511**).
3. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
4. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator is to have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - c. Operator Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - d. Nonspring-Return Motors for Dampers Larger Than **25 Sq. Ft. (2.3 sq. m)**: Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
 - e. Spring-Return Motors for Dampers Larger Than **25 Sq. Ft. (2.3 sq. m)**: Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
 - f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft. (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with **2- to 3-Inch wg (500 to 750 Pa)** of Pressure Drop or Face Velocities of **1000 to 2500 fpm (5 to 13 m/s)**: Increase running torque by 1.5.
 - 6) Dampers with **3- to 4-Inch wg (750 to 1000 Pa)** of Pressure Drop or Face Velocities of **2500 to 3000 fpm (13 to 15 m/s)**: Increase running torque by 2.0.
 - g. Coupling: V-bolt and V-shaped, toothed cradle.
 - h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
 - j. Power Requirements (Two-Position Spring Return): **[24 V dc][120 V ac][230 V ac]**.
 - k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
 - l. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
 - m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.

- n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.
 5. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.
 6. Combination Filter and Mixing Section:
 - a. Cabinet support members are to hold **[2-inch- (50-mm-)]<Insert dimension>** thick, pleated, flat, permanent or throwaway filters.
 - H. Air Blenders:
 1. Multiple-blade, air-mixer assembly is to mix air to prevent stratification, located immediately downstream of mixing box.
 - I. Materials:
 1. Steel:
 - a. ASTM A36/A36M for carbon structural steel.
 - b. ASTM A568/A568M for steel sheet.
 2. Stainless Steel:
 - a. Manufacturer's standard grade for casing.
 - b. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
 3. Galvanized Steel: ASTM A653/A653M.
 4. Aluminum: ASTM B209.
 5. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
 6. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a **[3000]<Insert time>**-hour salt-spray test in accordance with ASTM B117.
 - a. Standards:
 - 1) ASTM B117 for salt spray.
 - 2) ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
 - 3) ASTM B3359 for cross hatch adhesion of 5B.
 - b. Application: **[Immersion][Spray]**.
 - c. Thickness: **[1 mil (0.025 mm)]<Insert value>**.
 - d. Gloss: Minimum gloss of 60 on a 60-degree meter.
- 2.4 SOURCE QUALITY CONTROL
- A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.
 - B. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.
 - C. Fan Aerodynamic Performance Rating: Factory test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210.



- D. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- E. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- F. Water Coils: Factory tested to **300 psig (2070 kPa)** in accordance with AHRI 410 and ASHRAE 33.
- G. Steam Coils: Factory tested to **300 psig (2070 kPa)**, and to **200 psig (1380 kPa)** underwater, in accordance with AHRI 410 and ASHRAE 33.
- H. Refrigerant Coils: Factory tested to minimum **450-psig (3105-kPa)** internal pressure, and to minimum **300-psig (2070-kPa)** internal pressure while underwater, in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Replace with new insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF INDOOR, BASIC AIR-HANDLING UNITS

- A. Equipment Mounting:
 - 1. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Suspended Units: Suspend[**and brace**] units from structural-steel support frame using threaded steel rods and spring hangers. Coordinate sizes and locations of structural-steel support members with actual equipment provided. Comply with requirements for vibration isolation devices specified in [Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]
- C. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters

used during construction and testing with new, clean filters.

- E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using [NPS 1-1/4 (DN 32)]<Insert pipe size>, **ASTM B88, Type M (ASTM B88M, Type C)** copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- F. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection.
- G. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 - 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 - 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 - 6. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
 - 7. Comb coil fins for parallel orientation.
 - 8. Verify that proper thermal-overload protection is installed for electric coils.
 - 9. Install new, clean filters.
 - 10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for air-handling units include the following:
 - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. **[Replace fan and motor pulleys as required to achieve design conditions.]**
 - 2. Measure and record motor electrical values for voltage and amperage.
 - 3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.7 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.8 CLEANING

- A. After completing system installation and testing, adjusting, and balancing of air-handling unit and air-distribution systems, and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.



3.9 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner][Contractor]** will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
 - 2. Charge refrigerant coils with refrigerant and test for leaks.
 - 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Air-handling unit and components will be considered defective if unit or components do not pass tests and inspections.
 - 5. Prepare test and inspection reports.

3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 73 13 00



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 73 13 00A - INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Indoor, semi-custom air-handling units.

1.2 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each type and configuration of indoor, semi-custom air handling unit.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of indoor, semi-custom air-handling units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For vibration isolation[, **supports,][and **seismic restraints**] indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by**

the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators[, **supports**,][and **seismic restraints**] and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Restraint of internal components.
- C. Source quality-control reports.
- D. Startup service reports.
- E. Field quality-control reports.
- F. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: **[One]<Insert number>** set(s) for each air-handling unit.
 2. Gaskets: **[One]<Insert number>** set(s) for each access door.
 3. Fan Belts: **[One]<Insert number>** set(s) for each air-handling unit fan.

1.6 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of indoor, semi-custom air-handling units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: **<Insert number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Structural Performance: Casing panels are to be self-supporting and capable of withstanding positive/negative **[8-inch wg (2000 Pa)]<Insert value>** of internal static pressure, without exceeding a midpoint deflection of **[0.0042 inch/inch (0.0042 mm/mm)]<Insert dimensions>** of panel span.
- G. Casing Leakage Performance: ASHRAE 111, **[Class 6 leakage]<Insert leakage class>** or better at **[plus or minus 8 inch wg (2000 Pa)]<Insert pressure>**.
- H. Seismic Performance: Air-handling units are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Supply Fan:
 - 1. Type: **[DWDI, backward-inclined centrifugal fan][DWDI, forward-curved centrifugal fan][DWDI, airfoil centrifugal fan][SWSI, airfoil unhooused centrifugal fan]<Insert fan type>**.
 - 2. Class: AMCA 99, Section 14, **[Class I][Class II][Class III]**.
 - 3. Drive: **[V-belt][Direct]**.
 - 4. Number of Fan Wheels: **<Insert number>**.
 - 5. Fan Diameter: **<Insert value> inches (mm)**.
 - 6. Airflow: **<Insert value> cfm (L/s)**.
 - 7. Total Static Pressure: **<Insert value> inches wg (kPa)**.
 - 8. External Static Pressure: **<Insert value> inches wg (kPa)**.
 - 9. Speed: **<Insert rpm>**.
 - 10. Maximum Outlet Velocity: **<Insert value> fpm (m/s)**.

11. Motor:

- a. Size: **<Insert horsepower>**.
- b. Speed: **<Insert rpm>**.
- c. Volts: **[208][230][460]<Insert value> V**.
- d. Phase: **[Three]<Insert value>**.
- e. Hertz: **[60]<Insert number> Hz**.
- f. Full-Load Amperes: **<Insert value> A**.
- g. Minimum Circuit Ampacity: **<Insert value> A**.
- h. Maximum Overcurrent Protection: **<Insert amperage> A**.

12. Fan Discharge Sound Power, dB:

- a. 1st Octave: **<Insert value>**.
- b. 2nd Octave: **<Insert value>**.
- c. 3rd Octave: **<Insert value>**.
- d. 4th Octave: **<Insert value>**.
- e. 5th Octave: **<Insert value>**.
- f. 6th Octave: **<Insert value>**.
- g. 7th Octave: **<Insert value>**.
- h. 8th Octave: **<Insert value>**.

B. Fan: **[Return][Exhaust]**.

- 1. Type: **[DWDI, backward-inclined centrifugal fan][DWDI, forward-curved centrifugal fan][DWDI, airfoil centrifugal fan][SWSI, airfoil unhooded centrifugal plenum fan]<Insert fan type>**.
- 2. Class: AMCA 99, Section 14, **[Class I][Class II][Class III]**.
- 3. Drive: **[V-belt][Direct]**.
- 4. Number of Fan Wheels: **<Insert value>**.
- 5. Fan Diameter: **<Insert value> inches (mm)**.
- 6. Airflow: **<Insert value> cfm (L/s)**.
- 7. Total Static Pressure: **<Insert value> inches wg (kPa)**.
- 8. External Static Pressure: **<Insert value> inches wg (kPa)**.
- 9. Speed: **<Insert rpm>**.
- 10. Maximum Outlet Velocity: **<Insert value> fpm (m/s)**.
- 11. Motor:
 - a. Size: **<Insert horsepower>**.
 - b. Speed: **<Insert rpm>**.
 - c. Volts: **[208][230][460]<Insert value> V**.
 - d. Phase: **[Three]<Insert number>**.
 - e. Hertz: **[60]<Insert number> Hz**.
 - f. Full-Load Amperes: **<Insert value> A**.
 - g. Minimum Circuit Ampacity: **<Insert value> A**.
 - h. Maximum Overcurrent Protection: **<Insert amperage> A**.
- 12. Fan Inlet Sound Power, dB:
 - a. 1st Octave: **<Insert value>**.
 - b. 2nd Octave: **<Insert value>**.
 - c. 3rd Octave: **<Insert value>**.
 - d. 4th Octave: **<Insert value>**.
 - e. 5th Octave: **<Insert value>**.
 - f. 6th Octave: **<Insert value>**.

- g. 7th Octave: <Insert value>.
- h. 8th Octave: <Insert value>.

C. Preheat Coil:

1. Heat-Transfer Rate: <Insert value> Btu/h (kW).
2. Entering-Air Temperature: <Insert value> deg F (deg C).
3. Leaving-Air Temperature: <Insert value> deg F (deg C).
4. Face Area: <Insert value> sq. ft. (sq. m).
5. Maximum Face Velocity: <Insert value> fpm (m/s).
6. Maximum Air-Side, Static-Pressure Drop: <Insert value> inches wg (Pa).
7. Fin Spacing: Maximum <Insert number> fins per inch (per mm).
8. Minimum Number of Rows: <Insert number>.
9. Integral Face-and-Bypass Dampers: [Horizontal][Vertical], opposed-blade, [galvanized-steel][aluminum][extruded-aluminum] dampers with [zinc-plated]steel operating rods rotating in sintered bronze or nylon bearings mounted in a single [galvanized-steel][aluminum][extruded-aluminum] frame, with operating rods connected with a common linkage. Meeting edges of blades are to have gaskets and edge seals, and blades are to be mechanically fastened.
10. Water:
 - a. Water Flow: <Insert value> gpm (L/s).
 - b. Maximum Water Pressure Drop: <Insert value> feet of head (kPa).
 - c. Entering-Water Temperature: <Insert value> deg F (deg C).
 - d. Leaving-Water Temperature: <Insert value> deg F (deg C).
 - e. Tube Velocity: <Insert value> fpm (L/s).
11. Steam:
 - a. Steam Flow: <Insert value> lb/h (g/s).
 - b. Inlet Steam Pressure: <Insert value> psig (kPa).
 - c. Outer-Tube Diameter: <Insert value> inches (mm).

D. Heating Coil:

1. Heat-Transfer Rate: <Insert value> Btu/h (kW).
2. Entering-Air Temperature: <Insert value> deg F (deg C).
3. Leaving-Air Temperature: <Insert value> deg F (deg C).
4. Face Area: <Insert value> sq. ft. (sq. m).
5. Maximum Face Velocity: <Insert value> fpm (m/s).
6. Maximum Air-Side, Static-Pressure Drop: <Insert value> inches wg (Pa).
7. Number of Rows: <Insert number>.
8. Fin Spacing: Maximum <Insert number> fins per inch (per mm).
9. Water:
 - a. Water Flow: <Insert value> gpm (L/s).
 - b. Maximum Water Pressure Drop: <Insert value> feet of head (kPa).
 - c. Entering-Water Temperature: <Insert value> deg F (deg C).
 - d. Leaving-Water Temperature: <Insert value> deg F (deg C).
 - e. Tube Velocity: <Insert value> fpm (L/s).
10. Steam:
 - a. Steam Flow: <Insert value> lb/h (g/s).
 - b. Inlet Steam Pressure: <Insert value> psig (kPa).

E. Electric Heating Coil:

1. Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
2. Input: **<Insert kilowatts>.**
3. Volts: **[120][208][230]<Insert value> V.**
4. Phase: **[Single][Three].**
5. Full-Load Amperes: **<Insert value> A.**
6. Number of Steps: **<Insert number>.**

F. Cooling Coil:

1. Sensible Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
2. Total Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
3. Entering-Air, Dry-Bulb Temperature: **<Insert value> deg F (deg C).**
4. Entering-Air, Wet-Bulb Temperature: **<Insert value> deg F (deg C).**
5. Leaving-Air, Dry-Bulb Temperature: **<Insert value> deg F (deg C).**
6. Leaving-Air, Wet-Bulb Temperature: **<Insert value> deg F (deg C).**
7. Face Area: **<Insert value> sq. ft. (sq. m).**
8. Maximum Face Velocity: **<Insert value> fpm (m/s).**
9. Maximum Air-Side, Static-Pressure Drop: **<Insert value> inches wg (Pa).**
10. Number of Rows: **<Insert number>.**
11. Fin Spacing: Maximum **<Insert number> fins per inch (per mm).**
12. Water:
 - a. Water Flow: **<Insert value> gpm (L/s).**
 - b. Maximum Water Pressure Drop: **<Insert value> feet of head (kPa).**
 - c. Entering-Water Temperature: **<Insert value> deg F (deg C).**
 - d. Leaving-Water Temperature: **<Insert value> deg F (deg C).**
 - e. Tube Velocity: **<Insert value> fpm (L/s).**

13. Refrigerant:

- a. Refrigerant Type: **<Insert refrigerant type>.**

G. Prefilters:

1. Type: **<Insert type>.**
2. Face Dimensions, Each: **<Insert value> inches by inches (mm by mm).**
3. Depth: **<Insert value> inches (mm).**
4. Number of Filters, Wide by High: **<Insert number>.**
5. Access Location: **[Front][Back][Side][Bottom].**
6. Maximum or Rated Face Velocity: **<Insert value> fpm (m/s).**
7. Initial Resistance: **<Insert value> inches wg (Pa).**
8. Recommended Final Resistance: **<Insert value> inches wg (Pa).**
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating: **[MERV 1][MERV 2][MERV 3][MERV 4]**, and corresponding average arrestance in accordance with ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 13]<Insert value>**, in accordance with ASHRAE 52.2.

H. Final Filters:

1. Type: **<Insert type>**.
2. Face Dimensions, Each: **<Insert value> inches by inches (mm by mm)**.
3. Depth: **<Insert value> inches (mm)**.
4. Number of Filters, Wide by High: **<Insert number>**.
5. Access Location: **[Front][Back][Side][Bottom]**.
6. Maximum or Rated Face Velocity: **<Insert value> fpm (m/s)**.
7. Initial Resistance: **<Insert value> inches wg (Pa)**.
8. Recommended Final Resistance: **<Insert value> inches wg (Pa)**.
9. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 13]<Insert value>**, in accordance with ASHRAE 52.2.
- I. Dampers: **[Zone][Mixing dampers][Face and bypass]**.
- J. Sound Attenuators:
 1. Configuration: **[Straight][Elbow]**.
 2. Shape: **[Rectangular][Round]**.
 3. Attenuation Mechanism: **[Acoustic glass fiber][Packless]**.
 4. Maximum Pressure Drop: **<Insert value> inches wg (Pa)**.
 5. Length: **<Insert value> inches (mm)**.
 6. Face Dimension: **<Insert value> inches (mm) wide by <Insert value> inches (mm) high**.
 7. Face Velocity: **<Insert value> fpm (m/s)**.
 8. Dynamic Insertion Loss:
 - a. 1st Octave: **<Insert dBa>**.
 - b. 2nd Octave: **<Insert dBa>**.
 - c. 3rd Octave: **<Insert dBa>**.
 - d. 4th Octave: **<Insert dBa>**.
 - e. 5th Octave: **<Insert dBa>**.
 - f. 6th Octave: **<Insert dBa>**.
 - g. 7th Octave: **<Insert dBa>**.
 - h. 8th Octave: **<Insert dBa>**.
 9. Generated Noise:
 - a. 1st Octave: **<Insert dBa>**.
 - b. 2nd Octave: **<Insert dBa>**.
 - c. 3rd Octave: **<Insert dBa>**.
 - d. 4th Octave: **<Insert dBa>**.
 - e. 5th Octave: **<Insert dBa>**.
 - f. 6th Octave: **<Insert dBa>**.
 - g. 7th Octave: **<Insert dBa>**.
 - h. 8th Octave: **<Insert dBa>**.
- K. Steam Grid Humidifier:
 1. Humidification Rate: **<Insert value> lb/h (g/s)**.
 2. Steam Supply Pressure: **<Insert value> psig (kPa)**.
 3. Dry-Bulb Air Temperature at Discharge: **<Insert value> deg F (deg C)**.
 4. Wet-Bulb Air Temperature at Discharge: **<Insert value> deg F (deg C)**.
 5. Maximum Absorption Distance: **<Insert value> inches (mm)**.
 6. Number of Distribution **[Tubes][Manifolds]**: **<Insert number>**.
- L. Self-Contained Electric-Resistance Humidifier.

1. Humidification Rate: **<Insert value> lb/h (g/s).**
2. Dry-Bulb Air Temperature at Discharge: **<Insert value> deg F (deg C).**
3. Wet-Bulb Air Temperature at Discharge: **<Insert value> deg F (deg C).**
4. Maximum Absorption Distance: **<Insert value> inches (mm).**
5. Minimum Makeup Water Supply Pressure: **<Insert value> psig (kPa).**
6. Electric-Resistance Evaporation Chamber:
 - a. Power Input per Chamber: **<Insert number> kW.**
 - b. Number of Chambers: **<Insert number>.**

M. Self-Contained Gas-Fired Humidifier:

1. Humidification Rate: **<Insert value> lb/h (g/s).**
2. Dry-Bulb Air Temperature at Discharge: **<Insert value> deg F (deg C).**
3. Wet-Bulb Air Temperature at Discharge: **<Insert value> deg F (deg C).**
4. Maximum Absorption Distance: **<Insert value> inches (mm).**
5. Minimum Makeup Water Supply Pressure: **<Insert value> psig (kPa).**
6. Gas-Fired Generator:
 - a. Fuel Input: **<Insert value> Btu/h (kW).**
 - b. Fuel Pressure: **<Insert value> inches wg (kPa).**
7. Number of Distribution **[Tubes][Manifolds]: <Insert number>.**

N. Heat-Exchanger Humidifier:

1. Humidification Rate: **<Insert value> lb/h (g/s).**
2. Dry-Bulb Air Temperature at Discharge: **<Insert value> deg F (deg C).**
3. Wet-Bulb Air Temperature at Discharge: **<Insert value> deg F (deg C).**
4. Maximum Absorption Distance: **<Insert value> inches (mm).**
5. Minimum Makeup Water Supply Pressure: **<Insert value> psig (kPa).**
6. Steam to Heat Exchanger:
 - a. Supply Pressure at Control Valve: **<Insert value> psig (kPa).**
 - b. Condensing Rate: **<Insert value> lb/h (g/s).**

O. Air-to-Air Energy Recovery:

1. Type: **[Heat-wheel air-to-air energy recovery][Fixed-plate air-to-air energy recovery].**
2. Exhaust Air:
 - a. Airflow: **<Insert value> cfm (L/s).**
 - b. Face Velocity: **<Insert value> fpm (m/s).**
 - c. Summer:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - d. Winter:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**

- 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 5) Air Pressure Drop: **<Insert value> inches wg (Pa).**
3. Supply Air:
- a. Airflow: **<Insert value> cfm (L/s).**
 - b. Face Velocity: **<Insert value> fpm (m/s).**
 - c. Summer:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - d. Winter:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 5) Air Pressure Drop: **<Insert value> inches wg (Pa).**
 - e. Wheel Drive:
 - 1) Motor Size: **<Insert horsepower>.**
 - 2) Motor Electrical Characteristics:
 - a) Volts: **[120][208][230]<Insert value> V.**
 - b) Phase: **[Single][Three].**
 - c) Hertz: **[60]<Insert number> Hz.**
 - f. Effectiveness: **<Insert percentage>.**
4. Air Blender:
- a. Airflow: **<Insert value> cfm (L/s).**
 - b. Minimum Velocity: **<Insert value> fpm (m/s).**
 - c. Air Pressure Drop: **<Insert value> inches wg (Pa).**
5. Diffuser:
- a. Airflow: **<Insert value> cfm (L/s).**
 - b. Air Pressure Drop: **<Insert value> inches wg (Pa).**

2.3 INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Buffalo Air Handling]**
2. **[Carrier Global Corporation]**
3. **[Coil Company, LLC]**
4. **[Daikin Applied]**

5. [Dunham-Bush, Inc]
6. [ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]
7. [Trane]
8. [USA Coil & Air]
9. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
10. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Buffalo Air Handling]
2. [Carrier Global Corporation]
3. [Coil Company, LLC]
4. [Daikin Applied]
5. [Dunham-Bush, Inc]
6. [ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]
7. [Trane]
8. [USA Coil & Air]
9. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
10. <Insert manufacturer's name>

C. Unit Casings:

1. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.
2. Base Rail:
 - a. Material: [Galvanized steel][Welded structural steel]<Insert material>.
 - b. Height: [6 inches (150 mm)]<Insert dimension>.
3. Casing Joints: Hermetically sealed at each corner and around entire perimeter.
4. Double-Wall Construction:
 - a. Outside Casing Wall:
 - 1) Material, Galvanized Steel: Minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.
 - 2) Material, Aluminum: Minimum [16 gauge (1.3 mm)][14 gauge (1.6 mm)][12 gauge (2.0 mm)]<Insert value> thick.
 - 3) Material, Stainless Steel: Minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.
 - 4) Factory Finish: Provide [manufacturer's standard finish]<Insert special coating>.
 - b. Inside Casing Wall:
 - 1) Material, Galvanized Steel: [Solid][Perforated], minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - 2) Material, Aluminum: [Solid][Perforated], minimum [16 gauge (1.3 mm)][14 gauge (1.6 mm)]<Insert value> thick.
 - 3) Material, Stainless Steel: [Solid][Perforated], minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - 4) Antimicrobial Coating: Applied during the manufacturing process. [EPA approved][NSF approved][FDA listed].

5. Floor Plate:
 - a. Material, Galvanized Steel: **[Treadplate,]** minimum **[18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.7 mm)][10 gauge (3.5 mm)]<Insert value>** thick.
 - b. Material, Aluminum: **[Treadplate,]** minimum **[18 gauge (1.0 mm)][16 gauge (1.3 mm)][14 gauge (1.6 mm)][12 gauge (2.0 mm)][10 gauge (2.6 mm)]<Insert value>** thick.
 - c. Material, Stainless Steel: **[Treadplate,]** minimum **[18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.5 mm)]<Insert value>** thick.
 - d. Antimicrobial Coating: Applied during the manufacturing process. **[EPA approved][NSF approved][FDA listed]**.
6. Casing Insulation:
 - a. Materials: **[Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071][Injected polyurethane foam insulation][Glass-fiber insulation layered over injected foam in perforated interior casing sections to meet specified acoustic requirements]**.
 - b. Casing Panel R-Value: Minimum **[R-11][R-13]<Insert value>**.
 - c. Insulation Thickness: **[2 inches (50 mm)]<Insert dimension>**.
 - d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
7. Airstream Surfaces: Surfaces in contact with airstream are to comply with requirements in ASHRAE 62.1.
8. Static-Pressure Classifications:
 - a. For Unit Sections Upstream of Fans: Minus **[2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)][6-inch wg (1500 Pa)]<Insert value>**.
 - b. For Unit Sections Downstream and Including Fans: **[2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)][6-inch wg (1500 Pa)]<Insert value>**.
9. Panels, Doors, and Windows:
 - a. Panels:
 - 1) Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
 - 2) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement is to allow panels to be opened against airflow
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. At least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** wide by full height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>**.
 - b. Doors:
 - 1) Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
 - 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least **[18 inches (450 mm)][24 inches**

(600 mm)]<Insert dimension> wide by full height of unit casing up to a maximum height of [60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>.

- c. Windows:
 - 1) Construction: Fabricate windows in access panels and doors of double-glazed, safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
 - 2) Size: Minimum [6 inches (150 mm)]<Insert dimension>, square or round.
- d. Locations and Applications:
 - 1) Fan Section: [Doors][Panels][, with windows].
 - 2) Coil Section: [Panels].
 - 3) Access Section: [Doors][Panels][, with windows].
 - 4) Access Sections Immediately Upstream and Downstream of Coil Sections: [Doors][Panels][, with windows].
 - 5) Damper Section: [Doors][Panels][, with windows].
 - 6) Filter Section: [Doors][Panels] large enough to allow periodic removal and installation of filters.
 - 7) Access Sections Immediately Upstream and Downstream of Filter Sections: [Doors][Panels][, with windows].
 - 8) Mixing Section: [Doors][Panels][, with windows].
 - 9) Humidifier Section: [Doors][Panels][, with windows].
- e. Service Lights: <Insert number of watts>[LED]<Insert lamp type> vaporproof luminaire with individual switched junction box located [outside][inside], adjacent to each access door and panel.
 - 1) Locations: [Each section accessed with door or panel][Fan section]<Insert location>.
- f. Convenience Outlets: One 20-A duplex GFCI receptacle per location with junction box located on outside casing wall.
 - 1) Locations: [Each section accessed with a door or panel][Fan section]<Insert location>.

10. Condensate Drain Pans:

- a. Construction:
 - 1) Single-wall, [galvanized-steel or noncorrosive polymer][stainless steel] sheet.
 - 2) Double-wall, [galvanized-steel or noncorrosive polymer][stainless steel] sheet with space between walls filled with foam insulation and moisture-tight seal.
- b. Drain Connection:
 - 1) Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on [one end][both ends] of pan.
 - 2) Minimum Connection Size: [NPS 1 (DN 25)][NPS 2 (DN 50)]<Insert pipe size>.
- c. Slope: Minimum [0.125-in./ft. (10-mm/mm)]<Insert value> slope[, to comply with ASHRAE 62.1,] in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct

- water toward drain connection.
- d. Length: Extend drain pan downstream from leaving face [**for distance to comply with ASHRAE 62.1**]**<Insert distance>**.
- e. Width: Entire width of water producing device.
- f. Depth: A minimum of [**2 inches (50 mm)**]**<Insert dimension>** deep.
- g. **[Formed sections][Integral part of floor plating]**.
- h. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
- i. Units with stacked coils are to have an intermediate drain pan to collect condensate from top coil.

D. Fan, Drive, And Motor Section:

1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
2. Fans: Centrifugal, galvanized steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway.
 - b. Shaft Bearings:
 - 1) Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an [**L-50**]**<Insert bearing life rating>** rated life of [**200,000**]**<Insert number>** hours in accordance with ABMA 9.
 - 2) Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and two-piece, cast-iron housing[**with grease lines extended to outside unit**] and an [**L-50**]**<Insert bearing life rating>** rated life of [**200,000**]**<Insert number>** hours in accordance with ABMA 11.
 - 3) Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing[**with grease lines extended to outside unit**] and an [**L-50**]**<Insert bearing life rating>** rated life of [**200,000**]**<Insert number>**.
 - c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - 1) Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 - d. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
 - e. Plenum Fan Arrays: **[Contained][Uncontained]** as defined in AHRI 430. Steel or aluminum frame with inlet cone and structural framing around each fan built into an array of multiple fans. Provide **[backdraft][motorized]** dampers at each fan to prevent short circuiting of flow if one fan is not operating.
 - f. Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; **[steel][aluminum]** hub riveted to backplate and fastened to shaft with setscrews.
 - g. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; **[steel][aluminum]** hub swaged to backplate and fastened to shaft with setscrews.
 - h. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange

- i. and backplate; steel hub riveted to backplate and fastened to shaft with setscrews. Mounting: For internal vibration isolation[**and seismic control**]. Factory-mount fans with manufacturer's standard[**restrained**] vibration isolation mounting devices having a minimum static deflection of [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.
 - j. Shaft Lubrication Lines: Extended to a location outside the casing.
 - k. Flexible Connector: Factory fabricated with a fabric strip minimum [3-1/2 inches (89 mm)][5-3/4 inches (146 mm)]<Insert dimension> wide, attached to two strips of minimum [2-3/4-inch- (70-mm-) wide]<Insert dimension> by [0.028-inch- (0.7-mm-) thick, galvanized-steel sheet][0.032-inch- (0.8-mm-) thick, aluminum sheets].
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives are to comply with UL 181, Class 1.
 - a) Fabric Minimum Weight: **26 oz./sq. yd. (880 g/sq. m).**
 - b) Fabric Minimum Tensile Strength: **480 lbf/inch (84 N/mm)** in the warp and **360 lbf/inch (63 N/mm)** in the filling.
 - c) Fabric Minimum Service Temperature Range: **Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).**
- 3. Drive, Direct: Factory-mounted, direct drive.
- 4. Drive, Belt: Factory-mounted, V-belt drive, with adjustable alignment and belt tensioning, and with [1.5][1.25] service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards"; [0.146-inch- (2.7-mm-)]<Insert dimension> thick, [3/4-inch (20-mm)]<Insert dimension> diamond-mesh wire screen, welded to steel angle frame; prime coated.
- 5. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure Type: [Open, dripproof][Totally enclosed, fan cooled]<Insert type>.
 - d. Enclosure Materials: [Cast iron]<Insert material>.
 - e. Motor Bearings: <Insert requirements>.
 - f. Unusual Service Conditions:
 - 1) Ambient Temperature: <Insert deg C>.
 - 2) Altitude: <Insert feet (m)> above sea level.
 - 3) High humidity.
 - 4) <Insert conditions>.
 - g. Efficiency: Premium Efficient motors as defined in NEMA MG 1.
 - h. NEMA Design: <Insert designation>.
 - i. Motor Pulleys: Adjustable pitch for use with [5]<Insert number>-hp motors and smaller; fixed pitch for use with motors larger than [5]<Insert number> hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - j. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

- k. **<Insert unique motor characteristics>**.
 - l. Mount unit-mounted disconnect switches on **[exterior][interior]** of unit.
- 6. Comply with Section 262923 "Variable-Frequency Motor Controllers."
- 7. Variable-Frequency Motor Controller: Serving **[each fan individually][all fans combined]** in fan array.
 - a. Manufactured Units: Pulse-width modulated; **[constant torque][and][variable torque]<Insert application>** for **[Design A and Design B][inverter-duty]** motors.
 - b. Output Rating: Three phase; 10 to **[60 Hz, with voltage proportional to frequency throughout voltage range][66 Hz, with torque constant as speed changes]**; maximum voltage equals input voltage.
 - c. Unit Operating Requirements:
 - 1) Internal Adjustability:
 - a) Minimum Speed: 5 to 25 percent of maximum rpm.
 - b) Maximum Speed: 80 to 100 percent of maximum rpm.
 - c) Acceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - d) Deceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - e) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - 2) Self-Protection and Reliability Features:
 - a) Surge suppression.
 - b) Loss of input signal protection.
 - c) Under- and overvoltage trips.
 - d) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - e) Critical frequency rejection.
 - f) Loss-of-phase protection.
 - g) Reverse-phase protection.
 - h) Motor-temperature fault.
 - 3) Bidirectional autospeed search.
 - 4) Torque boost.
 - 5) Motor temperature compensation at slow speeds.
 - a) Panel-mounted operator station.
 - b) Historical logging information and displays.
 - c) Digital indicating devices.
 - 6) Control Signal Interface: Electric.
 - 7) Proportional Integral Directive (PID) control interface.
 - 8) DDC system for HVAC Protocols for Network Communications: **[ASHRAE 135]<Insert protocol type>**.
 - d. Line Conditioning:
 - 1) Input line conditioning.
 - 2) Output filtering.
 - 3) EMI/RFI filtering.
 - e. Bypass Systems:
 - 1) Bypass Mode: **[Manual operation only][Field-selectable automatic or manual]**.

- 2) Bypass Controller, Two-Contactor Style: With bypass and output isolating contactors[**and isolating switch**].
- 3) Bypass Controller, Three-Contactor Style: With bypass and input and output isolating contactors[**and isolating switch**].
- 4) Bypass Contactor Configuration: **[Full-voltage (across the line)][Reduced-voltage (autotransformer)]<Insert type>** type.

E. Coil Section:

1. General Requirements for Coil Section:

- a. Comply with AHRI 410.
- b. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
- c. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
- d. Coils are not to act as structural component of unit.

2. Preheat Coils:

- a. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
 - 1) Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
 - 2) Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - 3) Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 - 4) Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 - 5) Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - a) **[Magnetic][Mercury]** contactor.
 - b) Solid-state, stepless pulse controller.
 - c) Toggle switches, one per step.
 - d) Step controller.
 - e) Time-delay relay.
 - f) Pilot lights, one per step.
 - g) Airflow proving switch.
- b. Hot-Water Coils: **[Continuous circuit][Self-draining][Cleanable]**.
 - 1) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 2) Tube Material: **[Copper]<Insert material>**.
 - 3) Fin Type: Plate.
 - 4) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 5) Fin Spacing: Maximum **[10][12]<Insert spacing>** fins per inch (mm).
 - 6) Fin Thickness: **<Insert value> inches (mm)**.
 - 7) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 8) Headers:
 - a) Cast iron with[**cleaning plugs and**] drain and air vent tappings[**extended to exterior of unit**].

- b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
- 9) Frames: Channel frame, **[0.052-inch- (1.3-mm-) thick, galvanized steel][0.064-inch- (1.6-mm-) thick, galvanized steel][0.079-inch- (2.0-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, stainless steel]<Insert thickness><Insert material>**.
- 10) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
- 11) Coating: **[None][Corrosion-resistant coating]**.
- 12) Integral Face-and-Bypass Dampers: **[Horizontal][Vertical]**, opposed-blade, **[galvanized-steel][aluminum][extruded-aluminum]** dampers with **[zinc-plated]** steel operating rods rotating in sintered bronze or nylon bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]** frame, with operating rods connected with a common linkage. Meeting edges of blades are to have gaskets and edge seals, and blades are to be mechanically fastened.

c. Steam Coils: **[Distributed][Single tube]**.

- 1) Steam Outer-Tube Diameter: **<Insert value> inches (mm)**.
 - 2) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 3) Tube Material: **[Copper]<Insert material>**.
 - 4) Fin Type: Plate.
 - 5) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 6) Fin Spacing: Maximum **[8][10][12]<Insert spacing>** fins per inch (mm).
 - 7) Fin Thickness: **<Insert value> inches (mm)**.
 - 8) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 9) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
- 10) Frames: Channel frame, **[0.052-inch- (1.3-mm-) thick, galvanized steel][0.064-inch- (1.6-mm-) thick, galvanized steel][0.079-inch- (2.0-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, stainless steel]<Insert thickness><Insert material>**.
- 11) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
- 12) Coating: **[None][Corrosion-resistant coating]**.
- 13) Integral Face-and-Bypass Dampers: **[Horizontal][Vertical]**, opposed-blade, **[galvanized-steel][aluminum][extruded-aluminum]** dampers with **[zinc-plated]** steel operating rods rotating in sintered bronze or nylon bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]** frame, with operating rods connected with a common linkage. Meeting edges of blades are to have gaskets and edge seals, and blades are to be mechanically fastened.

3. Heating Coils:

a. Electrical Coils, Controls, and Accessories: Comply with UL 1995.

- 1) Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
- 2) Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent

chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.

- 3) Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
- 4) Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
- 5) Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - a) **[Magnetic][Mercury]** contactor.
 - b) Solid-state, stepless pulse controller.
 - c) Toggle switches, one per step.
 - d) Step controller.
 - e) Time-delay relay.
 - f) Pilot lights, one per step.
 - g) Airflow proving switch.

b. Hot-Water Coils: **[Continuous circuit][Self-draining][Cleaning]**.

- 1) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
- 2) Tube Material: **[Copper]<Insert material>**.
- 3) Fin Type: Plate.
- 4) Fin Material: **[Aluminum][Copper]<Insert material>**.
- 5) Fin Spacing: Maximum **[10][12]<Insert spacing>** fins per inch (mm).
- 6) Fin Thickness: **<Insert value> inches (mm)**.
- 7) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
- 8) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
- 9) Frames: Channel frame, **[0.052-inch- (1.3-mm-) thick, galvanized steel][0.064-inch- (1.6-mm-) thick, galvanized steel][0.079-inch- (2.0-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, stainless steel]<Insert thickness><Insert material>**.
- 10) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
- 11) Coating: **[None][Corrosion-resistant coating]**.

c. Steam Coils: **[Distributed][Single tube]**.

- 1) Steam Outer-Tube Diameter: **<Insert value> inches (mm)**.
- 2) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
- 3) Tube Material: **[Copper]<Insert material>**.
- 4) Fin Type: Plate.
- 5) Fin Material: **[Aluminum][Copper]<Insert material>**.
- 6) Fin Spacing: Maximum **[10][12]<Insert spacing>** fins per inch (mm).
- 7) Fin Thickness: **<Insert value> inches (mm)**.
- 8) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
- 9) Headers:

- a) Cast iron with[**cleaning plugs and**] drain and air vent tappings[**extended to exterior of unit**].
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
- 10) Frames: Channel frame, [0.052-inch- (1.3-mm-) **thick, galvanized steel**][0.064-inch- (1.6-mm-) **thick, galvanized steel**][0.079-inch- (2.0-mm-) **thick, galvanized steel**][0.0625-inch- (1.58-mm-) **thick, galvanized steel**][0.0625-inch- (1.58-mm-) **thick, stainless steel**]<Insert thickness><Insert material>.
 - 11) Coil Working-Pressure Ratings: [200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>.
 - 12) Coating: [None][Corrosion-resistant coating].
4. Cooling Coils:
- a. Chilled-Water Coil: [Continuous circuit][Self-draining][Cleanable].
 - 1) Piping Connections: [Threaded][Flanged], [same end][opposite ends] of coil.
 - 2) Tube Material: [Copper]<Insert material>.
 - 3) Tube Thickness: <Insert value> inches (mm).
 - 4) Fin Type: Plate.
 - 5) Fin Material: [Aluminum][Copper]<Insert material>.
 - 6) Fin Spacing: [0.125 inch (3.18 mm)][0.091 inch (2.31 mm)][0.071 inch (1.80 mm)][0.067 inch (1.70 mm)][0.056 inch (1.42 mm)][0.0075 inch (0.19 mm)]<Insert fins per inch (mm)>.
 - 7) Fin Thickness: <Insert value> inches (mm).
 - 8) Fin and Tube Joint: [Mechanical bond][Silver brazed].
 - 9) Headers:
 - a) Cast iron with[**cleaning plugs and**] drain and air vent tappings[**extended to exterior of unit**].
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 10) Frames: Channel frame, [0.052-inch- (1.3-mm-) **thick, galvanized steel**][0.064-inch- (1.6-mm-) **thick, galvanized steel**][0.079-inch- (2.0-mm-) **thick, galvanized steel**][0.0625-inch- (1.58-mm-) **thick, galvanized steel**][0.0625-inch- (1.58-mm-) **thick, stainless steel**].
 - 11) Coatings: [None][Corrosion-resistant coating].
 - 12) Working-Pressure Ratings: [200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>.
 - b. Refrigerant Coil:
 - 1) Tubes: [Copper]<Insert material>.
 - 2) Fins:
 - a) Material: [Aluminum][Copper]<Insert material>.
 - b) Fin Spacing: Maximum [12][10][8]<Insert spacing> fins per inch (mm).
 - 3) Fin and Tube Joints: Mechanical bond.
 - 4) Headers: [Seamless-copper headers with brazed connections]<Insert material and connections>.
 - 5) Frames: [Galvanized steel][Stainless steel]<Insert material frame>.

- 6) Coatings: **[None][Corrosion-resistant coating]**.
- 7) Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - a) Working Pressure: Minimum **300 psig (2070 kPa)**.

F. Air Filtration Section:

1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
2. High-efficiency particulate air (HEPA) filtration is specified in Section 234133 "High-Efficiency Particulate Air Filtration."
3. Gas-phase air filtration is specified in Section 234200 "Gas-Phase Air Filtration."
4. Panel Filters:
 - a. Description: **[Flat, non-pleated][Pleated]** factory-fabricated, self-supported, disposable air filters with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive.
 - d. Filter-Media Frame: **[Beverage board]<Insert material>** with perforated metal retainer, or metal grid, on outlet side.
5. Bag Filters:
 - a. Description: Factory-fabricated, dry, extended-surface, self-supporting filters with holding frames in steel, basket-type retainers.
 - b. Filter Unit Class: UL 900.
 - c. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pockets are maintained in tapered form by flexible internal supports under rated-airflow conditions.
 - d. Filter-Media Frame: **[Galvanized steel]<Insert material>**.
6. Cartridge Filters:
 - a. Description: Factory-fabricated, **[adhesive-coated]**disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pleats are maintained in pleated form under rated-airflow conditions by corrugated aluminum separators.
 - d. Filter Media Frame: **[Galvanized steel]<Insert material>**.
7. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
8. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
9. Front- or Back-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: **[Galvanized-steel][Aluminum]** framing members with access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
 - 1) Prefilters: Incorporate a separate **[2-inch- (50-mm-)]<Insert dimension>** thick track**[with spring clips]**, with same access as primary filter.
 - 2) Sealing: Full periphery foam gaskets.

- b. HEPA Filter Frames: **[Aluminum][Stainless steel]** framing members, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation operation. Bolted filter-sealing mechanism is to mount and continuously seal each individual filter.
 - 1) Prefilters: Incorporate a separate **[2-inch- (50-mm-)][4-inch- (50-mm-)]<Insert dimension>** thick track **[with spring clips]** with same access as primary filter.
 - 2) Sealing: **[Gasketed][or][gel]**, hand-crank locking mechanism to provide positive-sealing for each filter to ensure seal between filter elements to prevent bypass of unfiltered air.
 - c. Gas-Phase Air Filter Frames: **[Galvanized-steel][Aluminum]** framing members with access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
 - 1) Prefilters: Incorporate a separate **[2-inch- (50-mm-)]<Insert dimension>** thick track **[with spring clips]**.
 - 2) Sealing: **[Full periphery foam gaskets][Positive-sealing-device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air]**.
10. Side-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. **[Galvanized steel][Aluminum]** track.
 - 1) Prefilters: Incorporate an integral **[2-inch- (50-mm-)]<Insert dimension>** thick track with same access as primary filter.
 - 2) Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.
 - b. HEPA Filter Frames:
 - 1) Frames: Match inner casing and outer casing material, and insulation thickness. **[Aluminum][Stainless steel]** track.
 - 2) Prefilters: Incorporate an integral **[2-inch- (50-mm-)][4-inch- (100-mm-)]<Insert dimension>** thick track,
 - 3) Sealing: Incorporate positive-sealing clamping device on each filter between **[gasket][gel]** seal on all sides of filter cartridge frames to prevent bypass of unfiltered air.
 - c. Gas-Phase Air Filter Frames:
 - 1) Frames: Matching inner casing and outer casing material, and insulation thickness. **[Galvanized-steel][Aluminum]** track.
 - 2) Prefilters: Incorporate an integral **[2-inch- (50-mm-)]<Insert dimension>** thick track.
 - 3) Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.
- G. Dampers:
 1. Comply with requirements in Section 230923.12 "Control Dampers."
 2. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, **[galvanized-steel][aluminum][extruded-aluminum]<Insert material>** dampers with compressible jamb seals

and extruded-vinyl blade edge seals in [opposed][parallel]-blade arrangement with [zinc-plated]steel operating rods rotating in [stainless steel sleeve][sintered bronze or nylon]<Insert material> bearings mounted in a single [galvanized-steel][aluminum][extruded-aluminum]<Insert material> frame, and with operating rods connected with a common linkage. Leakage rate is not to exceed [4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa), leakage Class 1]<Insert requirement>[, tested, rated, and labeled in accordance with AMCA 511].

3. Face-and-Bypass Dampers: Opposed-blade, [galvanized-steel][aluminum][extruded-aluminum] dampers with [zinc-plated]steel operating rods rotating in sintered bronze or nylon bearings mounted in a single [galvanized-steel][aluminum][extruded-aluminum] frame and with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
4. Zone Dampers: Two single-blade, [galvanized-steel][aluminum][extruded-aluminum]<Insert materials> dampers offset 90 degrees from each other on [zinc-plated]steel operating rod rotating in sintered bronze or nylon bearings mounted in a single [galvanized-steel][aluminum][extruded-aluminum]<Insert material> frame. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
5. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
6. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator is to have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - c. Operator Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
 - e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
 - f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
 - g. Coupling: V-bolt and V-shaped, toothed cradle.

- h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
 - j. Power Requirements (Two-Position Spring Return): **[24 V dc][120 V ac][230 V ac]**.
 - k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
 - l. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
 - m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.
 - n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.
7. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.
 8. Combination Filter and Mixing Section:
 - a. Cabinet support members are to hold **[2-inch- (50-mm-)]<Insert dimension>** thick, pleated, flat, permanent or throwaway filters.
 9. Multiple-blade, air-mixer assembly is to mix air to prevent stratification, located immediately downstream of mixing box.
- H. Sound Attenuators:
1. General Requirements:
 - a. Factory fabricated.
 - b. Fire Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50, ASTM E84.
 - c. Airstream Surfaces: Surfaces in contact with the airstream are to comply with ASHRAE 62.1.
 2. Shape: **[Rectangular, straight][Round, straight][Rectangular, elbow][Round, elbow]**.
 3. Rectangular Silencer Outer Casing: **[Galvanized steel]<Insert material>**.
 4. Round Silencer Outer Casing: **[Galvanized steel]<Insert material>**.
 5. Inner Casing and Baffles: **[Galvanized steel]<Insert material>**.
 6. Principal Sound-Absorbing Mechanism:
 - a. Packless Type: Controlled impedance membranes and broadly tuned resonators without adsorptive media.
 - b. Dissipative Type: **[Polymer film-lined]**absorptive fill material.
 - 1) Fill Material: **[Inert and vermin-proof fibrous material]<Insert material type>**.
 - c. Joints: Lock formed and sealed, continuously welded or flanged.
- I. Humidifiers:
1. Direct-steam-injection humidifiers are specified in Section 238413.23 "Direct-Steam-Injection Humidifiers."
 2. Self-contained humidifiers are specified in Section 238413.29 "Self-Contained Humidifiers."
 3. Heat-exchanger humidifiers are specified in Section 238413.36 "Heat Exchanger Humidifiers."
- J. Air-To-Air Energy Recovery Units:

1. Heat Wheels:

a. Casing:

- 1) Galvanized steel, stainless steel, or aluminum with manufacturer's standard finish.
- 2) Integral purge section limiting carryover of exhaust air to between **[0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.5 percent at 400-Pa and 0.20 percent at 1000-Pa)]<Insert values>** differential pressure.
- 3) Casing seals on periphery of rotor, on duct divider, and on purge section.
- 4) Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.

b. Rotor, Aluminum or Polymer: Segmented wheel, strengthened with radial spokes[, **with nontoxic, noncorrosive, silica-gel desiccant coating**].

c. Rotor - Aluminum, Metallic, or Polymer: Segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating.

d. Drive: Fractional horsepower motor and gear reducer[, **with speed changed by variable-frequency controller**]. Permanently lubricated wheel bearings with an **[L-10]<Insert bearing life>[400,000 hours]<Insert hours>**.

e. Controls:

- 1) Starting relay, factory mounted and wired, and manual motor starter for field wiring.
- 2) Variable-frequency controller, factory mounted and wired, permitting input of field connected 4- to 20-mA or 1- to 10-V control signal.
- 3) Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
- 4) Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain **[exhaust temperature above freezing and]air** differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
- 5) Pilot-Light Indicator: Display rotor rotation and speed.
- 6) Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.

2. Fixed-Plate Sensible Heat Exchangers:

a. Casing: **[Aluminum][Galvanized steel]<Insert material>**.

b. Plates: Evenly spaced and sealed and arranged for **[counter][cross]** airflow.

c. Plate Material: **[Embossed aluminum][Stainless steel][High-density plastic]**.

d. Plate Coating: **[Epoxy]<Insert coating>**.

e. Bypass: Plenum within casing, with gasketed face-and-bypass dampers that have operating rods extended outside casing.

f. Heat-Exchanger Prefilters: **[1 inch (25 mm) thick, disposable][2 inches (50 mm) thick, disposable]<Insert type>[MERV 6]<Insert MERV>**.

K. Air Blenders:

1. Description: Static air mixer device to provide mixing of two airstreams to within **[plus/minus 6 deg F (3 deg C)]<Insert mixing differential>**.
2. Material: **[Galvanized steel][Aluminum]<Insert material>**.
3. Coating: **[None][Corrosion-resistant coating]**.

L. Diffusers:

1. Description: Velocity profile equalizer device for providing equalized airflow profile downstream of Type DWDI fans.
2. Material: [**Galvanized steel**][**Aluminum**]**<Insert material>**.

M. UV-C Lamp Systems:

1. Description:
 - a. UV-C lamp system consisting of power supply, power supply housing, wiring, UV lamp(s), lamp plug, lamp plug protector, encapsulated lamp, and lamp holder used for UV germicidal irradiation of cooling coil and condensate drain pan.
 - b. Factory installed and preengineered.
2. Standard: UL Category Code ABQK, HVAC accessories, air-duct mounted.
3. Lamps: High output, hot cathode.
4. Lamp-Holder Construction:
 - a. UV- and moisture-resistant materials and designed to connect the lamp to the plug.
 - b. Adjustable positioning.
5. Lamp-Clamp Construction:
 - a. UV- and moisture-resistant materials, water-tight connection.
 - b. Adjustable positioning.
6. Lamp Protection: Hermetically sealed to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.
7. Lamp Output: UV-C energy, primarily at the 254-nm wavelength with a 360-degree energy distribution.
8. Access Door Interlocks: Automatic disconnect on all access doors into UV-installed casing sections to shield servicing personnel from contact with light.
9. Power Supply: UL-listed, single-point electrical connection[**with service disconnect**].
10. Power Consumption: Maximum of [**15 W/sq. ft. (161 W/sq. m)**]**<Insert value>**.

2.4 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: **ASTM B 09 (ASTM B209M)**.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a

[3000]<Insert time>-hour salt-spray test in accordance with ASTM B117.

1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
 - c. ASTM B3359 for cross hatch adhesion of 5B.
2. Application: **[Immersion][Spray]**.
3. Thickness: **[1 mil (0.025 mm)]<Insert value>**.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.5 SOURCE QUALITY CONTROL

- A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.
- B. AHRI 1060 Certification: Test, rate, and label air-handling units that include air-to-air energy recovery devices in accordance with AHRI 1060.
- C. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.
- D. Fan Aerodynamic Performance Rating: Factory test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210.
- E. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- F. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- G. Water Coils: Factory tested to **300 psig (2070 kPa)** in accordance with AHRI 410 and ASHRAE 33.
- H. Steam Coils: Factory tested to **300 and 200 psig (2070 and 1380 kPa)** underwater in accordance with AHRI 410 and ASHRAE 33.
- I. Refrigerant Coils: Factory tested to minimum **450-psig (3105-kPa)** internal pressure and to minimum **300-psig (2070-kPa)** internal pressure while underwater, in accordance with AHRI 410 and ASHRAE 33.
- J. Witnessed Casing Leakage Tests:
 1. Pay for all expenses, for one representative designated by Owner, to travel to the factory to witness cabinet air-leakage testing on the specific assembled unit(s) prior to release for delivery to Project site.
 2. If the unit(s) does not meet specified leakage requirements, perform factory modifications and retest. Do not release unit for shipment until tested leakage is measured to be within specified leakage and leakage testing report has been accepted by Owner's designated representative.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

- A. Equipment Mounting:
 - 1. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Suspended Units: Suspend[**and brace**] units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in [**Section 230548 "Vibration and Seismic Controls for HVAC."**][**Section 230548.13 "Vibration Controls for HVAC."**]
- C. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
- E. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using [NPS 1-1/4 (DN 32)]<Insert pipe size>, ASTM B88, Type M (ASTM B88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- F. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.
- G. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

- A. [Engage a factory-authorized service representative to perform][Perform] startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is

- installed in motors, controllers, and switches.
- 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
- 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
- 6. Verify that zone dampers fully open and close for each zone.
- 7. Verify that face-and-bypass dampers provide full face flow.
- 8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
- 9. Comb coil fins for parallel orientation.
- 10. Verify that proper thermal-overload protection is installed for electric coils.
- 11. Install new, clean filters.
- 12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

- 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. **[Replace fan and motor pulleys as required to achieve design conditions.]**
- 2. Measure and record motor electrical values for voltage and amperage.
- 3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.7 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.8 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner][Contractor]** will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections

- for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. HEPA Filters: Pressurize housing to a minimum of **3-inch wg (750 Pa)** or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
5. HEPA Filters, Critical Applications: Pressurize housing to a minimum of **3-inch wg (750 Pa)** or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter for air leaks in accordance with ASME AG-1, pressure-decay method.
6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 73 13 00A



SECTION 23 73 13 00B - INDOOR, CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Indoor, custom air-handling units.

B. Related Requirements:

1. Section 237343.19 "Outdoor, Custom Air-Handling Units."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product information organized to show compliance with each performance requirement of "Performance Requirements" Article.
2. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
3. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
4. Include unit dimensions and weight.
5. Include cabinet material, metal thickness, finishes, insulation, and accessories.
6. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated. For fans operating at variable speeds include curves in [10]<Insert number> percent speed increments starting at design speed down to minimum speed.
 - b. Include fan-sound power ratings in all eight octave bands. Include inlet or outlet sound power levels to coincide with sound requirements indicated on Drawings.
 - c. Include fan construction and accessories. Submit sufficient information to show product compliance with requirements indicated.
 - d. Include dimensions and weight.
 - e. Include motor ratings, electrical characteristics, and motor accessories.
7. Vibration isolation product data with performance ratings. Uniquely identify and include information for each different isolator type and indicate for each air-handling unit where each isolator type is being used.
8. Include certified coil-performance ratings with system operating conditions indicated. Product data to include dimensions, dry and operating weight, volume of fluid contained, materials of construction, and performance ratings with system operating conditions indicated.
9. Casing insulation product data and performance ratings.
10. Access door and access panel product data and performance ratings.
11. Paint product data and performance ratings.
12. Electrical product data and performance ratings.
13. Metal grating product data and performance ratings.
14. Electric heater product data with performance ratings.
15. Steam humidifier product data with performance ratings.
16. Dampers product data, including housings, linkages, and operators with performance ratings.

17. Filters product data with performance characteristics.
18. Heat wheels product data with performance ratings.
19. Fixed plate heat exchangers product data with performance ratings.
20. Heat pipe heat exchangers product data with performance ratings.
21. Duct silencers product data with performance ratings.
22. Air blender product data with dimensions, weights, materials of construction, performance ratings, and installation requirements.
23. UV-C lamp systems product data with performance ratings.
24. <Insert requirements>.

B. Sustainable Design Submittals:

1. Product Data: Showing compliance with ASHRAE 62.1.
2. Product data indicating compliance with ASHRAE/IES 90.1.
3. Product Data: For air filtration performance.
4. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
5. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each type and configuration of indoor, custom air-handling unit.

1. Prepared by manufacturer's factory employees with review and sign-off by those individuals responsible for manufacturing the air-handling units.
2. Include plans, elevations, sections, and [mounting][attachment] details. **[For air-handling units consisting of multiple levels, create drawings for each level showing interrelationship of levels superimposed.]**
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, methods of field assembly, components, and location and size of each field connection.
4. Detail fabrication and assembly of indoor, custom air-handling units, as well as procedures and diagrams.
5. Indicate details of construction with materials description including applicable specified standards and material grades in sufficient detail for reviewers to evaluate point by point compliance with requirements indicated for each air-handling unit.
6. Use actual dimensions of internal equipment in preparing Shop Drawings. Identify mechanical equipment shown on Shop Drawings with equipment designations on Drawings.
7. Thickness and finish of all casing materials with cross references indicated where each is used. Uniquely identify and include information for each different casing construction.
8. Details for each unique casing joint and reinforcing. Indicate wall joints, wall to floor joints, wall to roof joints, floor joints, and roof joints.
9. Assembly details of base and casing for units consisting of multiple sections requiring field assembly.
10. Sizes and dimensioned locations of field connections for ductwork, piping, electrical, and controls.
11. Base and casing penetration and sealing details for factory-installed conduit.
12. Base and casing penetration and sealing details for factory-installed piping including coils **[and steam humidifiers]**.
13. Details of casing connections to field-installed ductwork.
14. Size, shape, and layout of base members including localized support of internal components.
15. Base materials, thickness, finishes, lifting provisions, and mounting requirements. Uniquely identify and include information for each different base construction. Clearly indicate for each air-handling unit.
16. Recommended points of field attachment with dimensioned locations.
17. Size and location of each access door, including clearing opening size, with door swing indicated.
18. Size and location of each access panel with service equipment superimposed to show relationship of panel to internal equipment.

19. Drain pans and associated piping, with sizes and locations dimensioned, including relationship to internal equipment.
20. Floor drains and associated piping, with sizes and locations dimensioned, including relation to internal equipment.
21. Coil framework and support including enlarged details showing framework attachment to air-handling unit base, coil attachment to framework, and means for individual coil removal.
22. Mounting details of all internal components, such as fans, filters, and dampers.
23. Hoist rails layout for internal equipment showing size of members, attachments to structure, and serviced equipment superimposed to indicate relationships.
24. Size and location of catwalks, handrails, ladders, and safety cages including construction details and details of attachment to air-handling unit base.
25. Location of UV-C lamp systems, service clearances, and mounting details.
26. Location of receptacles, service lights, and switches.
27. Location of motor controllers and disconnect switches.
28. Size and location of junction boxes used for interface with field electrical power.
29. Point-to-point electrical power wiring diagrams including wire size, conduit size, motor controllers sizes, switch types and ratings, receptacle types and ratings, service light fixture types, and ratings.
30. Point-to-point control wiring diagrams including cable types and sizes, conduit sizes, and connected control devices.
31. Point-to-point control tubing diagrams including tubing types and sizes, conduit sizes, and connection controls devices.
32. Control panel drawings drawn to scale showing detailed internal layout.
33. Indicate code, operating, and maintenance clearances drawn to scale using dashed lines.
34. Indicate weights of internal components, weight of each separately shipped section, and air-handling unit total weight.
35. **<Insert requirements>.**

D. Comparison Schedule:

1. Submit a schedule to indicate performance of equipment scheduled on Drawings directly compared to performance of submitted equipment.
2. Clearly identify each line in schedule to indicate "Scheduled" where indicating performance scheduled on Drawings and "Submitted" where indicating performance of submitted equipment.
3. Organize schedule to first indicate performance scheduled on Drawings on one line followed by line directly below that indicates performance of submitted equipment.
4. Comparison schedule shall follow arrangement and organization of scheduled information indicated on Drawings.
5. Submitted equipment shall have a value for each scheduled value indicated.

E. Delegated Design Submittals: For vibration isolation[**and seismic restraints**] indicated to comply with performance requirements and design criteria, including analysis data[**signed and sealed by the professional engineer responsible for their preparation**].

1. For seismic restraints indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Include design calculations for selecting seismic restraints.
2. **<Insert requirements>.**

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing

the items described in this Section and coordinated with all building trades.

- B. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - 4. Restraint of internal components.
- C. Source quality-control reports.
- D. Startup service reports.
- E. Field quality-control reports.
- F. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Bag Filters: **[One]<Insert number>** set(s) for each air-handling unit.
 - 2. Cartridge Filters: **[One]<Insert number>** set(s) for each air-handling unit.
 - 3. Panel Filters: **[One]<Insert number>** set(s) for each air-handling unit.
 - 4. Absolute Filters: **[One]<Insert number>** set(s) for each air-handling unit.
 - 5. Gas-Phase Filters: **[One]<Insert number>** set(s) for each air-handling unit.
 - 6. Access Door Gaskets: **[One]<Insert number>** set(s) for each **[unique]**access door.
 - 7. Fan Belts: **[One]<Insert number>** set(s) for each fan with belt-drive assembly.
 - 8. Heat Wheel Belts: **[One]<Insert number>** set(s) for each heat wheel with belt-drive assembly.
- B. Tool Kit: Manufacturer to provide a tool kit including special tools required for air-handling unit service. See "Accessories" Article for additional requirements.

1.6 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.7 FACTORY VISITS FOR PRODUCT INSPECTION

- A. While units are being manufactured, and during factory normal working hours, allow escorted access to manufacturing facility for [Owner][or][and][Owner's designated representative] to verify product compliance with requirements indicated.
 - 1. As many as <Insert number> persons shall visit factory for product inspection.
- B. Manufacturer shall provide [Owner][and][Architect] with written notice at least [30]<Insert number> business days before units go into assembly.
- C. Inspection visits shall be scheduled with manufacturer at least [10]<Insert number> business days before visit.
- D. Personnel making visits for purposes of product inspection shall comply with manufacturer requirements for visitors.

1.8 DELIVERY, STORAGE, HANDLING

- A. Deliver air-handling units with factory-installed shipping skids and lifting lugs; pack small components in factory-fabricated protective containers. Cover units with heat-shrinkable plastic sheeting suitable for shipping from point of manufacture to Project.
- B. Handle air-handling units carefully to avoid damage to components, casing, and finish. Do not install damaged components; replace and return damaged components to air-handling unit manufacturer.
- C. Store air-handling units in a clean dry place and protect them from weather and construction activities.
- D. Keep air-handling units fully covered and protected during construction. Remove dirt and debris and clean units to a factory-cleaned condition.
- E. Comply with manufacturer's written rigging and installation instructions for unloading air-handling units and moving them to their final locations.
- F. For air-handling units equipped with key locks on access doors, keep doors locked during construction.
 - 1. If access is required within air-handling units, only open the doors to sections that require access and lock doors at the end of each [workday][work shift]<Insert requirement>.
 - 2. Protect inside of air-handling units from damage and keep inside of units as clean as the factory-cleaned condition.
 - 3. Report observed abuse to <Insert entity> for immediate corrective action.

1.9 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of air-handling units that fails in materials or workmanship within specified warranty period.
 - 1. Warranty Period: <Insert number> year(s) from date of Substantial Completion.
- B. Extended warranties include, but are not limited to, the following:
 - 1. Complete Air-Handling Unit: [Two][Three][Five]<Insert number> years from date of Substantial Completion for entire air-handling unit and longer where indicated for individual components.

2. Air-Handling Unit Casing: [25][30]<Insert number> years from date of Substantial Completion.
3. Motors: [Two][Five]<Insert number> years from date of Substantial Completion.
4. Heat Wheels: [Five][10]<Insert number> years from date of Substantial Completion.
5. <Insert requirement>.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional [**specialist**][**engineer**], as defined in Section 014000 "Quality Requirements," to design air-handling units, [**vibration isolation**], [**and seismic restraints**] including comprehensive engineering analysis, using performance requirements and design criteria indicated.
- F. Casing Structural Performance:
 1. Floor: Capable of withstanding positive/negative [**8 inches wg (2000 Pa)**]<Insert value> of internal static pressure, without exceeding a deflection of [**L/300**][**L/360**]<Insert deflection> of span.
 2. Walls and Roof: Capable of withstanding positive/negative [**8 inches wg (2000 Pa)**]<Insert value> of internal static pressure, without exceeding a midpoint deflection of [**L/200**][**L/240**]<Insert deflection> of span.
- G. Casing Leakage Performance, ASHRAE 111: [**Class 3 leakage**]<Insert leakage class> or better at [**plus or minus 8 inches wg (2000 Pa)**]<Insert pressure>.
- H. Casing Leakage Performance: Comply with more stringent of the following requirements:
 1. ASHRAE 111, [**Class 3 leakage**]<Insert leakage class> or better at [**plus or minus 8 inches wg (2000 Pa)**]<Insert pressure>.
 2. Not more than [**0.5**]<Insert number> percent of the total unit airflow at [**8 inches wg (2000 Pa)**]<Insert pressure>.
- I. Casing Thermal Performance:
 1. Surface Condensation: Air-handling manufacturer shall evaluate potential for condensation and design and manufacture entire unit casing to prevent condensation at most extreme operating conditions encountered.
 2. Thermal Break: Incorporate a thermal break at each through metal path to prevent condensation from occurring on interior and exterior of casing.

3. U-Value: Overall U-value or equivalent R-value of casing shall not exceed governing codes and ASHRAE/IES 90.1, while considering the effects of metal-to-metal contact and thermal bridging in calculations.
- J. Air Tunnel Aerodynamic Performance: Position air-handling unit internal components and transition between internal components to maintain uniform airflow; minimize sound levels and energy consumption. Use methods indicated and other means to ensure compliance.
1. Use turning vanes if necessary to direct the air path.
 - a. Design, manufacture, and install vanes in accordance with applicable requirements in ASHRAE and SMACNA guidelines, handbooks, and standards.
 - b. Install vanes firmly in place so that no vane movement occurs at worst-case airflow capacity possible.
 2. Use fan inlet and discharge transitions and other devices to maximize system regain and minimize airborne sound levels.
 3. Center system components such as coils, fans, and filters, vertically and horizontally, in airstream.
 4. Maintain spacing between components such that airflow patterns to adjacent components are as uniform as possible and that component "dead spots" or "jetted areas" are avoided.
 5. Design and install internal structural supports, piping, and conduit that do not block airflow and impede performance of coils, fans, filters, and other unit components, and service space clearances.
- K. Air-Handling Unit Acoustical Performance:
1. Radiated Noise: Noise radiated from air-handling unit casing[**and openings not ducted**] shall not exceed following sound pressure levels when measured [**3 feet (900 mm)**]**<Insert distance>** away from any exterior surface of unit. Sound pressure levels indicated in each octave band are in decibels (dB) (reference 20 μ Pa).
 - a. 63 Hz: **<Insert value>** dB.
 - b. 125 Hz: **<Insert value>** dB.
 - c. 250 Hz: **<Insert value>** dB.
 - d. 500 Hz: **<Insert value>** dB.
 - e. 1000 Hz: **<Insert value>** dB.
 - f. 2000 Hz: **<Insert value>** dB.
 - g. 4000 Hz: **<Insert value>** dB.
- L. Casing Acoustical Performance:
1. Sound Absorption: Minimum acceptable sound absorption coefficient and noise reduction coefficient (NRC) of perforated inside casing assemblies when tested by an independent testing laboratory in accordance with ASTM C423 and ASTM E795.
 - a. 125 Hz: **<Insert value>** dB.
 - b. 250 Hz: **<Insert value>** dB.
 - c. 500 Hz: **<Insert value>** dB.
 - d. 1000 Hz: **<Insert value>** dB.
 - e. 2000 Hz: **<Insert value>** dB.
 - f. 4000 Hz: **<Insert value>** dB.
 - g. NRC: **<Insert value>**.
 2. Sound Transmission: Minimum acceptable sound transmission loss and STC of proposed cabinet construction when tested by an independent testing laboratory in accordance with ASTM E90 and

ASTM E413.

- a. 125 Hz: <Insert value> dB.
- b. 250 Hz: <Insert value> dB.
- c. 500 Hz: <Insert value> dB.
- d. 1000 Hz: <Insert value> dB.
- e. 2000 Hz: <Insert value> dB.
- f. 4000 Hz: <Insert value> dB.
- g. STC: <Insert value>.

M. Durability Performance: Design and manufacture air-handling units with underlying requirement to provide a highly durable piece of equipment.

- 1. Unit Life Expectancy: [25]<Insert number> years.
- 2. Supporting Documentation: Submit documentation showing proposed products to consider and include design features, components, and materials to satisfy requirement.

N. Extreme Operating Conditions:

- 1. Corrosive Environments: Air-handling unit manufacturer shall evaluate the quality and potential corrosiveness of air passing through air-handling units and propose additional protective finishes and better-quality materials of a heavier thickness if required to comply with requirements indicated.
 - a. Unless otherwise indicated, air-handling units for HVAC applications may use up to 100 percent of outdoor air or a mix of outdoor air with return air from habitable areas served. [**Projects located in coastal and industrial areas may require added protection.**]
 - b. Air-handling units circulating [Class 3][and][Class 4] exhaust air in accordance with ASHRAE 62.1 could potentially be hot, humid, and corrosive and may require added protection.
- 2. Humidity and Temperatures: Materials and components of air-handling units shall be suitable for use in low and high humidity and temperature extremes when operating under normal and abnormal conditions without permanent degradation or loss in material performance.

O. Safety:

- 1. Comply with OSHA regulations.
- 2. Exposed sharp edges and corners of metal shall be protected or rounded to prevent injury to personnel not wearing gloves.
- 3. Cover exposed ends of screws with plastic or metal covers to prevent injury to personnel coming in contact with screws.

P. Serviceability:

- 1. Hoisting Provisions: Fans and motors weighing more than [200 lb (91 kg)]<Insert weight> to have full-length hoist rails mounted over the equipment to facilitate service, removal, and replacement.
- 2. Mounting Location: Install internal components in readily accessible locations to facilitate ease of service and replacement.
- 3. Service Access:
 - a. Internal components shall be serviceable through access sections with doors indicated on Drawings.
 - b. Internal components shall be removable and replaceable through access doors or panels.

- c. Review requirements for access doors and panels indicated and recommend additional access doors and panels if required for uninhabited service, removal, and replacement of components.
- 4. Tripping Hazards: Floors in accessible sections of air-handling unit shall be free of standing seams, reinforcing, supports, or section splits located in the walking path that is capable of causing a tripping hazard. Locate section splits immediately adjacent to internal walls.
- Q. Quality: Type and thickness of materials indicated are the minimum acceptable. Provide better-quality materials of a heavier thickness if required to comply with performance requirements indicated.
 - 1. If manufacturer's standard construction exceeds requirements indicated, use manufacturer's standard construction.
 - 2. If manufacturer's standard construction does not comply with requirements indicated, modify manufacturer's standard construction to comply with requirements.
- R. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- S. Vibration Performance: Air-handling unit manufacturer shall evaluate vibration of internal components installed inside of air-handling units and include internal vibration isolation required to limit the vibration transmitted to the building at a low enough level that vibration is not perceived by building occupants.

2.2 CAPACITIES AND CHARACTERISTICS

- A. See equipment schedules on Drawings.

2.3 SOURCE LIMITATIONS

- A. Source all indoor **[and outdoor]** custom air-handling units from same manufacturer.
- B. Like components furnished with air-handling units shall be from same manufacturer.
- C. Air-handling units shall be manufactured in **[United States][United States or Canada][North America]<Insert requirement>**.
- D. **<Insert requirements>**.

2.4 INDOOR, CUSTOM AIR-HANDLING UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Air Enterprises, LLC]**

2. [Buffalo Air Handling]
3. [Climate Craft]
4. [Engineered Air]
5. [Environmental Air Systems]
6. [Haakon Industries]
7. [HUNTAIR; A Nortek Air Solutions Company]
8. [Temtrol; A Nortek Air Solutions Company]
9. [Trane; An Ingersoll Rand Company]
10. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Air Enterprises, LLC]
2. [Buffalo Air Handling]
3. [Climate Craft]
4. [Engineered Air]
5. [Environmental Air Systems]
6. [Haakon Industries]
7. [HUNTAIR; A Nortek Air Solutions Company]
8. [Temtrol; A Nortek Air Solutions Company]
9. [Trane; An Ingersoll Rand Company]
10. <Insert manufacturer's name>

C. Unit Arrangement and Configuration:

1. Arrangement: Project-specific arrangement and configuration of air-handling units as indicated on Drawings. Do not deviate from requirements indicated[**without submitting a formal request clearly describing each deviation and reason for each deviation, and only after receiving Architect's written acceptance**].
2. Mounting Requirements: [Indicated on Drawings][Units mounted on concrete housekeeping pads][Units mounted on structural floor][Units mounted on structural-steel frame][Units suspended from structure].
3. Multiple Sections: Each air-handling unit shall consist of multiple sections for field assembly to comply with requirements indicated on Drawings.
4. Multiple Sections, Splits: Air-handling unit manufacturer to determine number of sections and location of section splits required for each air-handling unit in accordance with the following criteria:
 - a. Physical size and weight of each section, on-site path of travel, and methods for erection and installation. Air-handling manufacturer to review criteria with Installer before preparing Shop Drawings.
 - b. Maximize physical size of each air-handling unit section considering, shipping, moving, erecting, and installation.
 - c. Limit physical size to fit within available building openings without altering building construction.
 - d. Minimize the number of air-handling unit sections requiring field assembly. Preference is for single-piece air-handling units where possible.
5. Knock-Down Unit Construction: Physical limitations of existing building(s) require a specialized installation consisting of field assembly of air-handling unit kit of parts shipped on pallets or in containers. Before preparing Shop Drawings, air-handling unit manufacturer shall review with Installer the on-site path of travel, physical size of each opening, weight limits, and methods for erection and installation.

D. Air-Handling Unit Base:

1. Performance:
 - a. Air-handling unit manufacturer shall design and assemble air-handling unit casing and internal components for attachment and support by air-handling unit structural base.
 - b. Design air-handling units to be lifted from only the air-handling unit structural base and not the casing.
 - c. Support air-handling units from only the perimeter base unless otherwise indicated on Drawings.
 - d. Air-handling unit manufacturer to size and locate intermediate structural base supports as required to comply with structural performance indicated for air-handling unit floors.
 - e. Level base before factory assembly of air-handling unit casing and internal components to ensure proper fit and alignment.
2. Structural Member Size:
 - a. Air-handling unit manufacturer shall select size of base members and construction of base to withstand the rigors of loading, unloading, shipping, and rigging without damage to air-handling unit components or misalignment of factory-assembled components.
 - b. Depth and weight of structural members shall be selected by air-handling unit manufacturer to comply with performance requirements indicated.
 - c. Depth of perimeter base members is not less than **[size indicated on Drawings][1/10 of the unit width][8 inches (200 mm) deep]<Insert requirement>**.
3. Structural Member Spacing: Positioned as required to comply with requirements indicated, but not to exceed **[24 inches (600 mm)]<Insert requirement>**.
4. Materials: **[Structural aluminum, ASTM B209 (ASTM B209M), Alloy 6061 T6][structural carbon steel, ASTM A36/A36M][structural stainless steel, ASTM A276/A276M, Type 304L][or][structural stainless steel, ASTM A276/A276M, Type 316L][as indicated on Drawings]**.
 - a. Perimeter Members: **[Angle][channel][I or W beam shapes][or][tube]**.
 - b. Intermediate Members (Spanning Full Width of Unit): **[Angle][channel][or][I or W beam shapes][or][tube]**.
 - c. Cross Members (Spanning Intermediate Members): **[Angle][channel][or][tube]**.
5. Carbon Steel Finish, Mill Galvanized: Mill-galvanized carbon steel with weld-damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.
6. Carbon Steel Finish: Carbon steel bases shall be shot-blasted, cleaned, prepared, and **[painted][or][hot-dip galvanized]** after fabrication.
7. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
 - a. Use welding materials with corrosion properties equal to material being welded.
8. Welding Procedures:
 - a. Structural Welding Codes: **[AWS D1.1/D1.1M for carbon steel][AWS D1.2/D1.2M for aluminum][AWS D1.6/D1.6M for stainless steel]**.
 - b. Join structural members to one another using **[continuous][or][stitch]** welds.
 - c. After welding and fabrication, deburr and grind exposed welds to provide smooth surfaces free of sharp edges.
9. Penetrations through Base Perimeter: Seal **[weld]** pipe, tubing, and conduit penetrations through base perimeter members to provide a watertight assembly.

10. Section Joints: Air-handling units consisting of multiple sections for field assembly shall be joined with structural joining plates.
 - a. Joining plate material type to match base.
 - b. Joining plate of thickness required to join sections without resulting in a permanent deflection, minimum **[1/2 inch (13 mm)]<Insert dimension>** thick.
 - c. Continuously weld joining plates to each mating end of base.
 - d. Joining plates shall not extend beyond outer edge of adjoining base.
 - e. Plates to include at least three equally spaced holes for field connection using factory-furnished threaded hardware of a nominal diameter of at least **[1/2 inch (13 mm)]<Insert diameter>**.
11. Lifting Provisions: Air-handling unit manufacturer to design and install lifting lugs of size and location required to comply with performance requirements indicated. **[Lifting lugs extending beyond the base shall be easily removable in the field after unit is installed.]**

E. Unit Casings:

1. Casing Assembly:
 - a. Appearance:
 - 1) Exposed exterior surfaces of casing shall have a neat and finished appearance free of standing seams, exposed reinforcing, and other casing protrusions more than **[0.25 inch (7 mm)]<Insert dimension>** beyond the exterior skin surface.
 - 2) Underside of air-handling units with finished installation exposed to view shall have finished appearance matching casing walls. Casing shall be recessed within the perimeter structural base to provide a single contiguous plane.
 - 3) Interior surfaces of casing shall have a neat and finished appearance free of standing seams, exposed reinforcing, and other casing protrusions more than **[0.25 inch (7 mm)]<Insert dimension>** beyond the skin surface.
 - b. Dissimilar Metals: Isolate dissimilar metals that are in contact to prevent galvanic action and corrosion.
 - c. Framing and Supports: Interconnect and support individual casing wall and roof panels using either formed panel construction or framed construction with structural support members. For framed casing construction, materials used to construct casing of structural support members shall be as follows:
 - 1) Casings with Aluminum Outer and Inner Skins: Aluminum extrusions in accordance with ASTM B211, Alloy 6063 T6.
 - 2) Casings with Galvanized-Steel Outer and Inner Skins: Galvanized steel.
 - 3) Casings with Galvanized-Steel Outer Skin and Aluminum or Stainless Steel Inner Skins: Stainless steel.
 - 4) Casings with Stainless Steel Outer and Inner Skins: Stainless steel.
 - d. Seals: Seal interior and exterior joints and seams to make casing air- and watertight. Trim factory-applied sealant flush with adjacent surface.
 - e. Double-Wall Casings: Consisting of insulation sandwiched between an outer and inner metal wall. Use double-wall casings to construct air-handling units unless septum casings are required.
 - f. Septum Casings: Triple-wall construction consisting of a solid metal inner wall sandwiched between insulation layers that are covered with metal walls. Use septum casings for applications having performance requirements that are not achievable with double-wall

- casings.
- g. Wall and Roof Penetrations: Seal voids around conduit, piping, and tubing penetrations.
- 1) Conduit, Pipe, and Tube Sizes and Smaller: **[NPS 3 (DN 80)]<Insert pipe size>**.
 - a) Seal void through casing with a nonhardening vapor-barrier caulk covered by an escutcheon on both interior and exterior sides of casing. Back caulk using formed insulation within a sheet metal sleeve.
 - b) Seal void using a friction fit neoprene or EPDM sheet material attached to casing using a bed of adhesive.
 - c) Cover penetration and sealing sheet material with metal escutcheon matching adjacent casing material.
 - d) Larger Conduit, Pipe, and Tube Sizes: Seal annular void using an adjustable compression-type sealing sleeve.
- h. Floor Penetrations: Route conduit, pipe, and tube within a floor-mounted pipe sleeve.
- 1) Sleeve:
 - a) Fabricate sleeve of aluminum[, **galvanized-steel,**] or stainless steel pipe.
 - b) Extend top of sleeve above adjacent floor surface to prevent standing water on floor from entering annular space of sleeve.
 - c) Seal[**weld**] sleeve to top of floor for an air- and watertight seal.
 - d) Seal annular void of sleeve using an adjustable compression seal **[or][nonhardening packing material]**.
- i. Floor Openings with Metal Grating:
- 1) Factory install walk-on safety gratings over any floor opening large enough to create a safety hazard for operators including, but not be limited to, supply-, return-, and exhaust-air openings.
 - 2) Bar Grating:
 - a) Materials: Use **[stainless steel grating for aluminum][stainless steel grating for stainless steel][hot-dip galvanized-steel grating for galvanized-steel][painted steel grating for painted steel]** floors.
 - b) Air-handling unit manufacturer shall select depth and thickness of grating bars to limit deflection to 1/360 of span when subjected to a dynamic load of not less than **[500 lb (227 kg)]<Insert weight>**.
 - c) Industry-standard welded grating with bars at least **1-1/2 inches (38 mm)** deep by at least **3/16 inch (5 mm)** thick with nominal **1-3/16-inch (30-mm)** main bar spacing and **4-inch (100-mm)** cross bar spacing.
 - d) Source: Product manufacturer specializing in metal gratings.
 - e) Grating bearing surface shall extend beyond clear opening in floor at least **[2 inches (50 mm)][3 inches (75 mm)]<Insert dimension>**.
 - 3) Mounting Frame:
 - a) Mount grating in a continuous structural angle or bar frame so no ends of grating bars are exposed. Top of frame to be flush with top of grating.
 - b) Secure grating to frame with threaded hardware, so grating does not move when walked on but can be easily removed from top to gain access behind grating.
 - c) Continuously weld mounting frame to air-handling unit floor.
 - d) Fasten mounting frame to air-handling unit floor with hardware and seal attachment air- and watertight.

- e) For applications with automatic dampers installed at floor openings, elevate height of mounting frame and grating to enclose entire damper assembly including jackshaft so walk-on surface of grating is above damper assembly.
 - j. Waterproof Floors: Continuously weld floor joints, seams, and penetrations to completely seal floor. Roll all edges of floor up at least **[1 inch (25 mm)]<Insert dimension>** to create a shallow tub capable of holding standing water.
 - k. Duct Connections - Direct to Casing: Frame and reinforce unit casing around perimeter of unit duct openings to accommodate direct attachment of field-installed ductwork. Coordinate requirements with Installer to accommodate field connection.
 - l. Duct Connections - Elevated Off Casing:
 - 1) Terminate with angle flange face elevated **[3 inches (75 mm)]<Insert dimension>** from exterior surface of casing.
 - 2) Flange Thickness: **[0.25 inch (6 mm)]<Insert dimension>**.
 - 3) Flange face with holes located not more than **[4 inches (100 mm)]<Insert dimension>** o.c., starting at corners, and sized for **[0.375-inch- (9-mm-)]** diameter, field-installed hardware.
 - 4) Size flange face to mate to full face of duct flange.
 - a) Clear inside dimension of unit connection to match clear inside dimension of duct.
 - b) For connections to acoustically lined ducts, increase unit flange face to accommodate thickness of liner so end of duct liner is concealed by air-handling unit flange.
 - m. **<Insert requirements>**.
2. Materials for Outer Skin of Casing Walls and Roofs:
- a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating; minimum (nominal) **[18 gauge (1.3 mm)]****[16 gauge (1.6 mm)]****[14 gauge (2.0 mm)]<Insert value>** thick.
 - b. Aluminum Solid Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, **[smooth]****[stucco-embossed texture]****[or]****[leather-grain texture]****<Insert finish>** finish; minimum (nominal) **[0.063 inch (1.6 mm)]****[0.080 inch (2.0 mm)]<Insert value>** thick.
 - c. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M, **[Type 304]****[Type 304L]****[Type 316]****[Type 316L]****<Insert type>**; No. **[2D]****[or]****[4]****<Insert finish>** finish; minimum (nominal) **[18 gauge (1.3 mm)]****[16 gauge (1.6 mm)]****[14 gauge (2.0 mm)]<Insert value>** thick.
 - d. Application: See Drawings for application of different materials indicated.
3. Materials for Inner Skin of Casing Walls and Roofs:
- a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating; minimum (nominal) **[20 gauge (1.0 mm)]****[18 gauge (1.3 mm)]****[16 gauge (1.6 mm)]<Insert value>** thick.
 - b. Galvanized-Steel Perforated Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating; minimum (nominal) **[20 gauge (1.0 mm)]****[18 gauge (1.3 mm)]****[16 gauge (1.6 mm)]<Insert value>** thick.
 - c. Aluminum Solid Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, **[smooth]****<Insert finish>** finish; minimum (nominal) **[0.032 inch (0.8 mm)]****[0.040 inch (1.1 mm)]****[0.063 inch (1.6 mm)]****[0.080 inch (2.0 mm)]<Insert value>** thick.
 - d. Aluminum Perforated Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, **[smooth]****<Insert finish>** finish; minimum (nominal) **[0.032 inch (0.8 mm)]****[0.040 inch (1.1**

- mm)][0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value> thick.
 - e. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D]<Insert finish> finish; minimum (nominal) [20 gauge (1.0 mm)][18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - f. Stainless Steel Perforated Sheet: ASTM A240/A240M or ASTM A480/A480M; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D]<Insert finish> finish; minimum (nominal) [20 gauge (1.0 mm)][18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - g. Application: See Drawings for application of different materials indicated.
4. Materials for Floor Walking Surface:
- a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; [G90 (Z275)]<Insert coating> coating; minimum (nominal) [14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.5 mm)]<Insert value> thick.
 - b. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M, [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D]<Insert finish> finish; minimum (nominal) [14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.6 mm)]<Insert value> thick.
 - c. Carbon Steel Diamond Treadplate: ASTM A786/A786M, painted finish; minimum (nominal) [0.125 inch (3.2 mm)][0.1875 inch (4.8 mm)]<Insert value> thick.
 - d. Aluminum Diamond Treadplate: ASTM B632/B632M, Alloy 6061 T6; mill finish; minimum (nominal) [0.125 inch (3.2 mm)][0.1875 inch (4.8 mm)]<Insert value> thick.
 - e. Stainless Steel Diamond Treadplate: ASTM A793; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; mill finish; minimum (nominal) [0.125 inch (3.2 mm)][0.1875 inch (4.8 mm)]<Insert value> thick.
 - f. Application: See drawings for application of different materials indicated.
5. Materials for Underside of Floor Insulation:
- a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; [G90 (Z275)]<Insert coating> coating; minimum (nominal) [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - b. Aluminum Solid Sheet: ASTM B209 (ASTM B209M); Alloy 3003-H14, [smooth]<Insert finish> finish; minimum (nominal) [0.040 inch (1.1 mm)][0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value> thick.
 - c. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D][4]<Insert finish> finish; minimum (nominal) [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - d. Application: See Drawings for application of different materials indicated.
6. Materials for Internal Walls:
- a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; [G90 (Z275)]<Insert coating> coating; minimum (nominal) [16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.
 - b. Aluminum Solid Sheet: ASTM B209 (ASTM B209M); Alloy 3003-H14, smooth finish; minimum (nominal) [0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value> thick.
 - c. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M, [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. 2D finish; minimum (nominal) [16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.
 - d. Application: See Drawings for application of different materials indicated.
7. Surfaces in Contact with Airstream:
- a. Comply with ASHRAE 62.1 and NFPA 90A.
 - b. Glass or mineral-fiber insulation installed behind perforated metal shall be encapsulated to

prevent insulation fibers from entering the airstream by using a **[polymer sheet material][or][tightly woven glass cloth material that does not impact the acoustical absorption properties of insulation]**.

8. Insulation for Casing Walls and Roofs Not Exposed to Airstream:
 - a. Materials Not Exposed to Airstream: **[Glass or mineral-fiber board][injected or sprayed polyurethane foam][or][polyurethane foam board]** insulation with a minimum nominal density of **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)]<Insert density>**.
 - b. R-Value: Minimum **[R-8][R-10][R-12][R-16]<Insert value>**.
 - c. Thickness: Minimum **[2 inches (50 mm)][2.5 inches (68 mm)][3 inches (75 mm)][4 inches (100 mm)]<Insert dimension>**.
 - d. Insulation shall completely fill the casing cavity so no voids exist.
9. Insulation for Casing Walls and Roofs Exposed to Airstream:
 - a. Materials Exposed to Airstream: Glass or mineral-fiber board insulation with a minimum density of **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density>**.
 - b. R-Value: Minimum **[R-8][R-10][R-12][R-16]<Insert value>**.
 - c. Thickness: Minimum **[2 inches (50 mm)][2.5 inches (68 mm)][3 inches (75 mm)][4 inches (100 mm)]<Insert dimension>**.
 - d. Insulation shall completely fill the casing cavity so no voids exist.
10. Insulation for Casing Floors:
 - a. Materials: **[Glass or mineral-fiber board insulation][injected or sprayed polyurethane foam][or][polyurethane foam board]** insulation with a minimum nominal density of **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)]<Insert density>**.
 - b. R-Value: Minimum **[R-8][R-10][R-12][R-16]<Insert value>**.
 - c. Thickness: Minimum **[2 inches (50 mm)][2.5 inches (68 mm)][3 inches (75 mm)][4 inches (100 mm)]<Insert dimension>**.
 - d. Insulation shall completely fill the casing cavity so no voids exist.
11. Access Doors:
 - a. Application: **[Install access doors in air-handling units at locations indicated on Drawings][Install access doors downstream and upstream of all internal components]<Insert requirement>**.
 - b. Adjustment: Design doors for field adjustment capable of maintaining specified leakage rate.
 - c. Mounting Height: Install bottom of door frame within **[2 inches (50 mm)]<Insert dimension>** of air-handling unit floor walking surface. **[Where internal conditions require access doors to be mounted higher above air-handling unit floor, include permanent retractable stairs inside and outside of air-handling unit to limit stair risers to 6 inches (150 mm).]**
 - d. Performance: Leakage as required to satisfy overall unit leakage performance indicated, but not more than **[1.0 cfm (0.47 L/s)]<Insert leakage rate>** per door when tested at 10 inch wg (2500 kPa).
 - e. Fabrication: Formed and reinforced, constructed of same materials and thicknesses as casing. **[Where doors are installed in casing walls with perforated interior, install doors with solid interior.]**
 - f. Swing: Arrange doors to be opened against pressure unless otherwise indicated on Drawings.
 - g. Frame: **[Extruded aluminum with thermal break][galvanized steel][or][stainless steel]**

- with **[welded]** mitered corners.
- h. Handles:
- 1) Secure door closed using not less than two **[roller-style]** latches with handles located at quarter points along door height.
 - 2) If three latches with handles are included, install one at midpoint of door height and equally space others.
 - 3) Air-handling unit manufacturer has option to use a multipoint latching mechanism that is operable from a single door handle located at midpoint of door height, but secures door to frame at top, bottom, and handle location.
 - 4) Include door handles on outside and inside of door to allow operator access to open and close door from outside and inside of unit.
 - 5) Field adjustable to accommodate changes to fit and gasket compression.
 - 6) Durable product capable of withstanding repeated opening and closing of door while operating under design pressure without damage.
- i. Hinges: **[Minimum of two hinges][minimum of three hinges][or][full-length, concealed, stainless steel piano hinge]**.
- j. Gasket:
- 1) Design: Specially formed with an internal air chamber specifically designed to seal on two surfaces without taking a permanent set.
 - 2) Dual Gaskets: Primary and secondary gasket.
 - 3) Location: Install gaskets around entire perimeter of doors or frames.
 - 4) Material: EPDM, neoprene, or santoprene.
 - 5) Protection: Seat gasket in a protective metal ribbed chamber integral to door or door frame to protect gasket from damage by operator incidental contact.
 - 6) Service: Field replaceable.
 - 7) Adhesive-backed tape-type gaskets adhered to a single flat surface are unacceptable.
- k. Size of Door Frame Clear Opening: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.
- 1) Width: At least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** clear inside of door frame.
 - 2) Height: Full clear height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>** clear inside of door frame.
 - 3) Door sizes indicated on Drawings.
- l. Safety Latches and Stops:
- 1) Safety Latches: Install safety latch with retainers on outward swing doors that do not open against pressure to allow restricted travel for purpose of pressure relief and so that doors do not open uncontrollably due to inside pressure.
 - 2) Stops: Install cushioned door stops on inward swinging doors where necessary to limit door travel that could potentially damage the door or internal components.
- m. Tie-Backs: Install tie-backs with retainers on **[outward-swinging]** access doors to hold doors in an open position during service.
- n. Locks: Include each access door with an integral key lock. Pad locks are unacceptable.
- 1) Incorporate key lock into door handle where feature is available.
 - 2) A common key shall be used to lock and unlock access doors of **[each][all]** air-handling unit(s).
 - 3) Include **[two]<Insert value>** keys **[for each air-handling unit]**.



- 4) Lock access doors at factory to ensure that unauthorized access is in place before air-handling unit packaging and shipment.
- o. Windows:
- 1) Construction: Fabricate windows with frame mounted in access doors of double-glazed safety glass with an airspace between panes and interior and exterior seals.
 - 2) Condensation Control: Install desiccant material in airspace between panes if necessary to prevent condensation from forming on glazing.
 - 3) Clear Viewing Size: Minimum **[6 inches (150 mm)][8 inches (200 mm)][12 inches (300 mm)]<Insert dimension>**, square **[or round]**.
 - 4) Mounting Location: Center window in door width. For doors up to **[60 inches (1500 mm)]<Insert dimension>** high, locate top of window **[6 inches (150 mm)]<Insert dimension>** below top of door. For taller doors, locate center of windows at optimal viewing height, approximately **[60 inches (1500 mm)]<Insert dimension>** above floor adjacent to unit.
 - 5) Application: Install windows in **[all access doors][only access doors servicing fans][only access doors servicing fans and filters][only access doors servicing coils, dampers, heat wheels, fans, filters, and UV-C lamps]<Insert requirement>**.
- p. Nameplates:
- 1) On each access door, include a nameplate defining the access to service within. Nameplates shall be included for, but not be limited to, the following:
 - a) Dampers.
 - b) Filters.
 - c) Gas-phase filters.
 - d) Cooling coils.
 - e) Heating coils.
 - f) Electric heaters.
 - g) Duct silencers.
 - h) Heat wheels.
 - i) Fixed plate exchangers.
 - j) Heat pipe heat exchangers.
 - k) UV-C lamp systems.
 - l) Supply fans.
 - m) Exhaust fans.
 - n) Return fans.
 - o) Humidifiers.
 - p) Air blenders.
 - q) **<Insert items>**.
 - 2) Air-handling unit designation.
 - 3) Where door access is to multiple components, list all components accessed. For example: Filter/Cooling Coil.
 - 4) For each door that does not open against static pressure, include a warning sign stating: "DANGER: DOOR UNDER PRESSURE. DO NOT OPEN WITH FAN ON."
 - 5) Lettering Size and Style: At least **[1-inch- (25-mm-)]<Insert dimension>** high, block style.
 - 6) Material: Lettering engraved in black plastic on a white plastic back. Engraving shall penetrate through black plastic so lettering reads white.
 - 7) Attachment: Attach nameplates to door using high-strength bonding cement and **[stainless steel]**screws.

- 8) Mounting Location:
- a) For access doors without windows, locate top of nameplate [6 inches (150 mm)]<Insert dimension> from top of door and center in door width.
 - b) For access doors with windows, locate nameplate directly [above][or][below] window frame and center in door width.
 - c) Align nameplates of all doors for uniform placement.

12. Access Panels:

- a. Performance: Leakage as required to satisfy overall unit leakage performance indicated.
- b. Fabrication: Formed and reinforced panels of same material and thickness as casing.
- c. Fasteners: Adjustable, reusable type for multiple operations without degradation due to reuse. [**Do not use screws capable of stripping.**]
- d. Arrangement: Panels removable from exterior side of casing.
- e. Gasket: EPDM, neoprene, or santoprene similar to access doors, applied around entire perimeter of panels or frames.
- f. Location and Size:
 - 1) Coils: Oversized access panel to allow removal and replacement without impacting adjacent casing.
 - 2) Electric Heaters: Oversized access panel to allow removal and replacement without impacting adjacent casing.
 - 3) Fans: Oversized access panel to allow removal and replacement of entire fan assembly [including base]without impacting adjacent casing.
 - 4) Heat Wheels and Heat Exchangers: Oversized access panel to allow removal and replacement of internal components without impacting adjacent casing.
 - 5) Humidifiers: Oversized access panel to allow removal and replacement without impacting adjacent casing.
 - 6) <Insert component>.
- g. Nameplates:
 - 1) On each access panel, include a nameplate defining the access to service within. Nameplates shall be included for, but not be limited to, the following:
 - a) Cooling coils.
 - b) Heating coils.
 - c) Electric heaters.
 - d) Heat wheels.
 - e) Fixed plate exchangers.
 - f) Heat pipe heat exchangers.
 - g) Humidifiers.
 - h) Supply fans.
 - i) Exhaust fans.
 - j) Return fans.
 - k) <Insert description>.

F. Internal Structural Supports:

1. General:

- a. Air-handling unit manufacturer shall design and assemble air-handling unit internal structural supports for attachment and support by air-handling unit structural base.
- b. Factory install structural supports for internal support casing if required to comply with casing structural performance.

- c. Factory install hoist beams and rails over equipment to comply with performance requirements for service.
- 2. Structural Member Size and Spacing:
 - a. Size: Air-handling unit manufacturer shall select size of members and construction to do the following:
 - 1) Withstand the rigors of loading, unloading, shipping, and rigging without damage to air-handling unit components or misalignment of factory-assembled casing and components.
 - 2) Comply with performance requirements indicated.
 - b. Spacing: Positioned as required to comply with requirements.
- 3. Materials: **[Structural aluminum, ASTM B209 (ASTM B209M), Alloy 6061 T6][structural carbon steel, ASTM A36/A36M][structural stainless steel, ASTM A276/A276M, Type 304L][or][structural stainless steel, ASTM A276/A276M, Type 316L][as indicated on Drawings].**
 - a. Structural Supports: **[Angle][channel][I or W beam][or][tube]** shapes selected by air-handling unit manufacturer for application.
 - b. Hoist Beams for Internal Components (Spanning Full Width of Unit): I or W beam shapes.
- 4. Carbon Steel Finish, Mill Galvanized: Mill galvanized carbon steel with weld damaged areas cleaned, prepared and painted with galvanized paint after fabrication.
- 5. Carbon Steel Finish: Carbon steel bases shall be shot-blasted, cleaned, prepared and **[painted][or][hot-dip galvanized]** after fabrication.

G. Centrifugal Fan Arrays:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ebm-papst Inc.]**
 - b. **[Greenheck Fan Corporation]**
 - c. **[Lau Fan]**
 - d. **[Loren Cook Company]**
 - e. **[Rosenberg USA, Inc.]**
 - f. **[Twin City Fan & Blower]**
 - g. **[ZIEHL-ABEGG Inc.]**
 - h. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ebm-papst Inc.]**
 - b. **[Greenheck Fan Corporation]**
 - c. **[Lau Fan]**
 - d. **[Loren Cook Company]**
 - e. **[Rosenberg USA, Inc.]**
 - f. **[Twin City Fan & Blower]**

- g. [ZIEHL-ABEGG Inc.]
 - h. <Insert manufacturer's name>
3. Sourcing Option: In lieu of sourcing fan array assemblies from a specialty fan manufacturer, air-handling unit manufacturer has option to furnish in-house fan array assemblies that achieve equal or better performance while complying with other requirements indicated.
4. Operating Performance:
- a. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - 1) Add additional static pressure to fan scheduled total static pressure.
 - 2) If fan motor horsepower is increased, notify Architect.
 - b. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.
 - c. Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.
 - d. Scheduled motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
 - e. As a minimum, fans shall have AMCA class indicated on Drawings.
 - 1) Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.
 - 2) If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - 3) AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.
 - f. Motor starting torque shall exceed fan speed-torque requirements.
 - g. Airflow Profile:
 - 1) Fan arrangement within fan array shall produce a uniform airflow and velocity profile across air-handling unit air tunnel when measured [12 inches (300 mm)]<Insert dimension> upstream of fan inlet and [48 inches (1200 mm)]<Insert dimension> downstream of fan inlet.
5. Vibration Balance:
- a. Each fan/motor assembly shall be factory balanced to AMCA 204, [BV-5, Balance Quality Grade G1.0][BV-4, Balance Quality Grade G2.5][BV-3, Balance Quality Grade G6.3][Balance Quality Grade indicated on Drawings]<Insert fan vibration balance requirements> or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be [10][20]<Insert number> percent of design speed.
 - b. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 - c. Submit test reports as an informational submittal for Project record.
6. Vibration Isolation: Install vibration isolation on each fan/motor assembly in the fan array, except vibration isolation may be omitted on fans/motor assemblies balanced to AMCA 204, BV-5, with a maximum residual imbalance of 0.22-in./s (5.6-mm/s) peak, filter in.
7. Operation and Service Requirements:
- a. Remaining fans in array shall continue to operate with one or multiple failed fans.
 - b. Each fan/motor assembly of fan array shall be capable of lock-out/tag-out procedure

- without interrupting operation of other fans in the array.
 - c. Each fan/motor assembly shall be controlled through a variable-frequency controller, except for fans with electronically commutated (EC) motors having integral motor controls.
 - 1) Include a dedicated variable-frequency controller for each fan/motor assembly in the fan array.
 - 2) If fan array is served from a single variable-frequency controller, include a redundant variable-frequency controller with automatic switchover in event of primary variable-frequency controller failure.
 - d. A single mechanical, electrical, and control device failure shall not result in a fan array available capacity of less than [33]<Insert number> percent of air-handling unit total scheduled airflow capacity.
 - e. Fan wheel/motor assembly shall pass through the air-handling unit access door servicing fans. Entire individual fan assembly shall pass through the door to the room where air-handling unit is located.
 - f. Design and incorporate features to permit safe, rapid, and economical maintenance.
8. Airflow Measurement, Local Indication, and Remote Monitoring:
- a. Each fan within fan array shall include airflow measurement indication in **cfm (L/s)**.
 - b. Include airflow totalization of all operating fans in fan array.
 - c. Airflow measurement instrumentation shall not restrict or deflect air travel through fan and shall not impact fan air and sound performance.
 - d. Include digital display of individual fan airflow and total fan array airflow on face of fan control panel.
 - e. Include a 4- to 20-mA output signal for remote monitoring of total fan array airflow.
9. Fan Array Local Control:
- a. Include fan control panel with operator interface to control fan array locally through the fan control panel and to switch to control of fan array through a remote-control source.
 - b. Local control shall include on/off operation [**and speed adjustment**]for entire fan array and each individual fan/motor in fan array.
10. Fan Array Remote Control:
- a. Include fan control panel with control interface for remote control.
 - b. Fan array on/off operation shall be remotely controlled through a single hardwired digital output signal.
 - c. Fan array speed shall be remotely controlled through a single hardwired analog (4- to 20-mA) output signal.
11. Fan Base, Stackable Fan Units:
- a. Mount fan/motor on [**aluminum**][**galvanized-steel**][or][**powder-coated steel**] base.
 - b. Include base and vibration isolators in accordance with requirements indicated.
 - c. Weld structural members to form a rigid base.
 - d. Size and design the base construction to withstand the rigors of shipping and rigging.
 - e. Include the base with lifting lugs or holes.
12. Fan Frame:
- a. Construct frame of [**aluminum**][**galvanized steel**][or][**powder-coated steel**].
 - b. Reinforce and brace frame to prevent excessive deflection and pulsation.

- c. Include stiffeners to form a rigid frame that is free of structural resonance and vibration.
13. Fan Panel:
- a. Construct fan panel of [**continuously welded**][**aluminum**][**galvanized steel**][or][**powder-coated steel**].
 - b. Reinforce and brace fan panel to prevent excessive deflection and pulsation.
 - c. Include stiffeners to form a rigid panel that is free of structural resonance and vibration.
14. Fan Inlet Cone:
- a. Include a precision-spun or die-formed, matched inlet and wheel cone to ensure streamlined airflow into the wheel and full loading of fan blades.
 - b. Inlet cone shall be a smooth hyperbolic shape.
 - c. Inlet cone shall be a single piece, constructed of aluminum or powder-coated steel.
 - d. Fasten inlet cone to fan panel using bolts, nuts, and washers to provide a positive and secure attachment that can be field removable.
15. Fan Wheel:
- a. Fan blades shall be a true hollow airfoil shape, welded to backplate and wheel cone.
 - b. Construct blades of aluminum, reinforced for AMCA fan class.
 - c. Design blades to provide smooth airflow over all surfaces of blade.
 - d. Construct fan hubs of aluminum with integral bracing for extra strength and stiffness.
 - 1) Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.
 - 2) Clean surfaces of castings by blasting, pickling, or any other standard method.
 - 3) Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.
 - 4) Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.
 - e. Hubs shall be keyed and setscrewed to motor shaft for positive attachment.
 - f. Construct wheel backplates of aluminum.
 - g. Select entire rotating assembly so first critical speed is at least **[30]<Insert number>** percent greater than fan design speed and at least **[20]<Insert number>** percent greater than maximum speed in AMCA fan class.
16. Fan Drive:
- a. Direct drive, arrangement 4 in accordance with AMCA 99.
 - b. Adjust wheel width and diameter to match motor speed while providing performance scheduled.
 - c. Fasten fan wheel directly to motor shaft using a key in motor shaft and setscrew.
 - d. Construct motor base and pedestal supports of [**aluminum**][**galvanized steel**][or][**powder-coated steel**].
 - e. Fan Speed Limitation:
 - 1) Fan speed at design conditions indicated shall not exceed speed on motor nameplate.
 - 2) Do not select fans to operate at motor speeds greater than motor nameplate.
17. Fan Motors: See "Fan Motors" Article for ac motors.
18. Fan Motors, Electronically Commutated (EC):



- a. Description: EC, variable-speed, dc, programmable brushless motor.
 - b. Features:
 - 1) Integral controller/inverter operates wound stator and senses rotor position to electronically commutate the stator.
 - 2) Controller shall control motor speed either through manual adjustment locally at fan array control panel or through a remote 0- to 10-V-dc control signal.
 - 3) Motor Mounting: Coordinate with driven equipment; suitable for mounting with motor shaft in either horizontal or vertical position.
 - c. Performance:
 - 1) Altitude: Suitable for operation at site altitude.
 - 2) Electrical Characteristics: Suitable for operation with field power source. Coordinate with electrical Installer.
 - 3) Energy Efficiency: Complying with governing energy codes; **[80]<Insert number>** percent or higher maintained throughout entire operating range.
 - 4) Power Factor: **[0.9]<Insert value>** or higher at full load.
 - 5) Service Factor: 1.0 or higher.
 - 6) Speed Control: Variable, zero to 100 percent.
 - a) Synchronous speed rotation with no slip losses.
 - b) Gradual ramp-up to set point upon receiving a start signal.
 - c) Soft speed change ramps.
 - d) Able to overcome reverse rotation without impact.
 - e) Control airflow within 5 percent of set point regardless of static pressure.
 - d. Temperature: Suitable for operation in ambient temperature range encountered.
 - e. Thermal Protection:
 - 1) Automatically breaks electrical power to motor when temperature exceeds a safe value.
 - 2) Automatically resets and restores power when temperature returns to normal range.
 - f. Bearings: Sealed and permanently lubricated ball bearings.
 - g. Enclosure: ODP or TEFC.
 - h. Insulation: Class B or Class F.
 - i. Rotor: Permanent magnet with near zero rotor losses that operates independent of motor current.
 - j. Materials and Construction:
 - 1) Enclosure and Frame: Aluminum, painted steel, or stainless steel.
 - 2) End Brackets: Cast aluminum.
 - 3) Shaft: Steel or stainless steel.
 - 4) Motor Leads: Pin or screw terminals.
 - 5) Nameplates: Manufacturer's standard.
 - 6) Paint: Manufacturer's standard.
19. Fan Enclosure:
- a. Include each fan in fan array with integral single-wall enclosure constructed of solid **[aluminum][galvanized-steel][or][powder-coated steel]** sheet.
 - b. Enclosure shall not increase fan array length beyond size indicated on Drawings.
 - c. Enclosure shall not add static pressure loss.
 - d. Enclosure shall provide a physical separation between operating adjacent fans to prevent

negative performance.

20. Fan Sound Silencing Enclosure:

- a. Include each fan of fan array with integral sound silencer enclosure to reduce the bare fan discharge sound levels by at least **[8][15]<Insert value>** dBs through octave band frequencies from 125 to 8000 Hz.
- b. Enclosure shall not increase the fan array length beyond size indicated on Drawings.
- c. Silencing enclosure shall not add static pressure loss.
- d. Double-wall construction consisting of sound-absorbing insulation sandwiched between a solid metal outer skin and perforated metal inner skin.
 - 1) Outer Skin Material: **[Aluminum][Galvanized steel][Powder-coated steel]**.
 - 2) Inner Skin: Material **[Aluminum][Galvanized steel][Powder-coated steel]**.
 - 3) Insulation Material: **[Mineral fiber][mineral fiber wrapped in a tight woven fiberglass cloth or polymer sheet][or][fiber free]**.
- e. Enclosure shall provide a physical separation between operating adjacent fans to prevent a negative performance.

21. Backdraft Damper:

- a. Include each fan in the fan array with a backdraft damper at the fan **[inlet][or][outlet]** to prevent air circulation through a fan that is not operating.
- b. Open backdraft damper when fan is operating and close when fan is not operating.
- c. Design backdraft damper assembly to operate with little to no static pressure loss with fan operating throughout entire operating range from design to minimum airflow.
 - 1) Add damper pressure loss to fan scheduled total static pressure.
 - 2) If pressure loss requires a change field electrical power, air-handling unit manufacturer shall be responsible for associated cost of change.
- d. Fasten backdraft damper assembly to fan panel or enclosure using hardware designed for easy removal by maintenance personnel.
- e. Dampers shall not create measurable additional noise above the sound level of fan.
- f. Dampers shall not vibrate or rattle.
- g. Construct dampers of extruded aluminum, stainless steel, or powder-coated steel.

22. Blank-off Panels:

- a. Include **[one][two][10 percent of]<Insert value>** blank-off panel(s) with each air-handling unit fan array for use by operators in the field to prevent air circulation through any of the fans in fan array that are not operating.
- b. Design blank-off panels for attachment to fan panels using easily removable and reusable hardware.
- c. Construct blank-offs of aluminum, stainless steel, or powder-coated steel sheets, not less than **[0.07 inch (1.8 mm)]<Insert dimension>** thick.
- d. Mount fan blank-off panels in the fan inlet access section for convenient operator access and use in the future.

23. Protective Screens:

- a. Include easily removable safety screens where fan inlet and outlet are exposed to maintenance personnel, including walk-in air-handling unit plenums.
 - 1) Safety screens are not required on fan inlets and outlets with backdraft dampers.

- b. Expanded-metal or wire screens, fastened to a flat bar perimeter frame.
 - c. Screens shall comply with OSHA requirements.
 - d. Screens and frame shall be constructed of aluminum, stainless steel, or powder-coated steel.
 - e. Fasten screens to fan using removable and reusable hardware designed for easy removal by maintenance personnel.
24. Hardware: Hex-head, high-strength **[carbon steel with corrosion-resistant coating][or][300 series stainless steel]**.
25. Nameplates:
- a. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
 - b. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
 - c. Locate nameplates in a highly visible location on motor side of fan.
 - d. Provide the Following Information on Nameplate: **[Engrave][stamp][or][label]**.
 - 1) Manufacturer, address, phone number, and website address.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Manufacturing date.
 - 5) Fan size.
 - 6) Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).
 - 7) Design airflow.
 - 8) Design static pressure.
 - 9) Design fan speed.
 - 10) AMCA fan class.
 - 11) **<Insert requirement>**.
26. Air-Handling Unit Factory Assembly:
- a. Internal Access: Include each fan with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Removal and Replacement: Each fan wheel and motor shall be independently removable and replaceable through a removable access door installed in air-handling unit casing.
 - c. Stackable Fan Arrays: Construct frame work from aluminum[, **galvanized steel,**][, **painted steel,**] or stainless steel.
 - d. Panel-Mounted Fan Array Supports:
 - 1) Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.
 - 2) Construct frame work from aluminum[, **galvanized steel,**][, **painted steel,**] or stainless steel.
- H. Centrifugal Plenum Fans:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Greenheck Fan Corporation]**
 - b. **[Loren Cook Company]**
 - c. **[New York Blower Company (The)]**

- d. **[Twin City Fan & Blower]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Greenheck Fan Corporation]**
 - b. **[Loren Cook Company]**
 - c. **[New York Blower Company (The)]**
 - d. **[Twin City Fan & Blower]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain fans from single source from single manufacturer.
4. Operating Performance:
- a. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - 1) Add additional static pressure to fan scheduled total static pressure.
 - 2) If fan motor horsepower is increased, notify Architect.
 - b. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.
 - c. Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.
 - d. Motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
 - e. Fan air performance ratings shall be based on tests in accordance with ASHRAE 51/AMCA 51 and AMCA 210.
 - f. Base fans sound ratings on AMCA 300 and calculation methods in accordance with AMCA 301.
 - g. As a minimum, fans shall have AMCA class indicated on Drawings.
 - 1) Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.
 - 2) If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - 3) AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.
 - h. Motor starting torque shall exceed fan speed-torque requirements.
5. Vibration Balance:
- a. Each fan/motor assembly shall be factory balanced to AMCA 204, **[BV-5, Balance Quality Grade G1.0][BV-4, Balance Quality Grade G2.5][BV-3, Balance Quality Grade G6.3][Balance Quality Grade indicated on Drawings]<Insert fan vibration balance requirements>** or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be **[10][20]<Insert number>** percent of design speed.
 - b. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 - c. Submit test reports as an information submittal for Project record.
6. Operation and Service Requirements:

- a. Each fan/motor assembly shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in air-handling unit.
 - b. Design and incorporate features to permit safe, rapid, and economical maintenance.
7. Fan Base:
- a. Mount fan, motor, and drive on a structural-steel or an aluminum base; except, where indicated on Drawings, install fan on a concrete-filled inertia base.
 - b. Include base and vibration isolators in accordance with requirements indicated.
 - c. Electrically weld the base.
 - d. Size and design the base construction to withstand the rigors of shipping and rigging.
 - e. Include the base with lifting lugs or holes.
 - f. Construct base with gusseted brackets to accommodate spring isolators indicated.
8. Fan Panel:
- a. Construct fan panel of aluminum or powder-coated steel.
 - b. Support fan wheel and bearings from a structural aluminum or powder-coated steel framework.
 - c. Reinforce and brace fan panel to prevent vibration and pulsation.
 - d. Include stiffeners to form a rigid panel that is free of structural resonance and vibration.
9. Fan Inlet and Wheel Cone:
- a. Precision-spun or die-formed, matched inlet and wheel cone to ensure streamlined airflow into the wheel and full loading of blades.
 - b. Inlet and wheel cones shall be hyperbolic.
 - c. Inlet cone shall be a single piece, constructed of aluminum or powder-coated carbon steel.
 - d. Fasten inlet cone to fan panel using bolts, nuts, and washers to provide a positive and secure attachment that can be field removable.
 - e. Inlet cones that are held in place using retaining clips are unacceptable.
10. Fan Wheel:
- a. Fan blades shall be a true hollow airfoil shape, [**continuously**] welded to backplate and wheel cone.
 - b. Construct blades of aluminum, reinforced for AMCA fan class and operating conditions scheduled.
 - c. Design blades to provide smooth and aerodynamic airflow over all surfaces of blade.
 - d. Construct fan hubs of cast aluminum or cast iron, ASTM A48/A48M Class 20A and better, with integral bracing for extra strength and stiffness.
 - 1) Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.
 - 2) Clean surfaces of castings by blasting, pickling, or other standard method.
 - 3) Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.
 - 4) Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.
 - e. Hubs shall be keyed and setscrewed to shaft for positive attachment.
 - f. Construct the wheel backplates of aluminum.
 - g. Statically and dynamically balance fan wheel before fan is assembled.
 - h. Select entire rotating assembly so first critical speed is at least [30]<Insert number> percent greater than fan design speed and at least [20]<Insert number> percent greater

than maximum AMCA class speed.

11. Fan Drive:

- a. Direct drive, arrangement 4 in accordance with AMCA 99 for single-width, single-inlet fans.
- b. Adjust wheel width and diameter to match motor speed while providing performance scheduled.
- c. Fasten fan wheel directly to motor shaft using a key and setscrew as previously specified.
- d. Construct motor base and pedestal of aluminum or powder-coated carbon steel plate.
- e. Fan Speed Limitation: Fan speed at design conditions indicated shall not exceed speed on motor nameplate for direct-drive applications. Do not select fans to operate at motor speeds greater than motor nameplate.

12. Protective Screens: Factory furnish and install protective screens on fan inlet and discharge.

- a. **[Expanded metal][or][welded wire]** welded to a **[painted carbon steel][or][stainless steel]** frame.
- b. Screens shall comply with OSHA requirements.
- c. Screens shall be constructed of **[painted carbon][or][stainless]** steel.
- d. Fasten screens to fan frame for easy removal by maintenance personnel.

13. Welding:

- a. Use AWS- or ASME-certified welders to weld materials required by application.
- b. **[Where indicated on Drawings,][All]**welds shall be continuous full-penetration welds.

14. Hardware: Hex-head, high-strength **[carbon steel][or][300 series stainless steel]**.

15. Nameplates:

- a. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
- b. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
- c. Locate nameplates in a highly visible location on motor side of fan.
- d. Provide the Following Information on Nameplate: **[Engrave][stamp][or][label]**.
 - 1) Manufacturer, address, phone number, and website address.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Manufacturing date.
 - 5) Fan size.
 - 6) Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).
 - 7) Design airflow.
 - 8) Design static pressure.
 - 9) Design fan speed.
 - 10) AMCA fan class.
 - 11) **<Insert requirement>**.

16. Air-Handling Unit Factory Assembly:

- a. Internal Access: Include each fan with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
- b. Removal and Replacement: Each fan shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
- c. Fan Supports:

- 1) Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.
- 2) Construct frame work from aluminum[, **galvanized steel**,][, **painted steel**,] or stainless steel.

I. Housed Centrifugal Fans:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Greenheck Fan Corporation]**
 - b. **[Howden American Fan Company]**
 - c. **[Loren Cook Company]**
 - d. **[New York Blower Company (The)]**
 - e. **[Twin City Fan & Blower]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Greenheck Fan Corporation]**
 - b. **[Howden American Fan Company]**
 - c. **[Loren Cook Company]**
 - d. **[New York Blower Company (The)]**
 - e. **[Twin City Fan & Blower]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain fans from single source from single manufacturer.
4. Operating Performance:
 - a. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - 1) Add additional static pressure to fan scheduled total static pressure.
 - 2) If fan motor horsepower is increased, notify Architect.
 - b. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.
 - c. Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.
 - d. Motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
 - e. Fan air performance ratings shall be based on tests in accordance with ASHRAE 51/AMCA 51 and AMCA 210.
 - f. Base fan sound ratings on AMCA 300 and calculation methods in accordance with AMCA 301.
 - g. As a minimum, fans shall have AMCA class indicated on Drawings.
 - 1) Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.
 - 2) If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - 3) AMCA class selected shall be capable of accommodating a plus 10 percent increase

to fan static pressure indicated on Drawings.

- h. Motor starting torque shall exceed fan speed-torque requirements.
- 5. Vibration Balance:
 - a. Each fan/motor assembly shall be factory balanced to AMCA 204, **[BV-5, Balance Quality Grade G1.0][BV-4, Balance Quality Grade G2.5][BV-3, Balance Quality Grade G6.3][Balance Quality Grade indicated on Drawings]<Insert fan vibration balance requirements>** or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be **[10][20]<Insert number>** percent of design speed.
 - b. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 - c. Submit test reports as an information submittal for Project record.
- 6. Operation and Service Requirements:
 - a. Each fan/motor assembly shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in air-handling unit.
 - b. Design and incorporate features to permit safe, rapid, and economical maintenance.
- 7. Fan Base:
 - a. Mount fan, motor, and drive assembly on an open structural base, except where Drawings indicate an inertia base.
 - b. Continuously weld base structural members constructed of **[aluminum][carbon steel][or][stainless steel]**.
 - c. **[Air-handling unit][or][fan]** manufacturer to size and design the fan base construction to withstand the rigors of shipping and rigging.
 - d. Fabricate base with lifting lugs or holes and gusseted brackets to accommodate spring isolators indicated.
- 8. Fan Housing:
 - a. Continuously weld housing constructed of **[aluminum][carbon steel][or][stainless steel]** sheets, plates, and structural shapes.
 - b. Support fan housing and shaft bearings from a rigid structural framework.
 - c. Brace fan housing to prevent vibration and pulsation with external stiffeners to form a rigid housing that is free of operating resonance.
 - d. Extend fan housing side sheets not more than **[1/2 inch (13 mm)]<Insert dimension>** past fan scroll.
 - e. Fan Cut-off: Designed for pressure distribution required by the application.
 - f. Fan Blast Area: At least **[80]<Insert number>** percent of fan outlet area.
 - g. Wheel Removal: Construct fan housing for fan wheel(s) removal through the inlet opening when the inlet cone is removed.
 - h. Split Housings: For fans with wheel diameters nominal **[49 inches (1225 mm)]<Insert dimension>** and larger, include diagonally flanged, gasketed, and bolted split housings.
 - i. Access Doors: Quick-opening, gasketed, with heavy-duty latches.
 - 1) Conform to housing contour.
 - 2) Locate in 5 o'clock or 7 o'clock position about the end of the shaft and position to gain internal access.
 - 3) Maximize size of square access door up to **[24 inches (600 mm)]<Insert dimension>**.

- j. Drains: **[NPS 1 (DN 25)]<Insert pipe size>** female NPT threaded half coupling welded to lowest point of fan housing. Position the drain connection to accommodate field-installed drain piping. Include each drain coupling with a stainless steel threaded plug.
 - k. Flanged Discharge Connections: Welded flanged discharge with a matching companion flange having evenly spaced holes for threaded hardware.
 - l. Flanged Inlet Connections: Welded flanged inlet with a matching companion flange having evenly spaced holes for threaded hardware.
9. Fan Inlet and Wheel Cones:
- a. Precision-spun or die-formed, matched inlet and wheel cones with hyperbolic shape to ensure streamlined airflow into the wheel and fully load the blades for efficient aerodynamic performance.
 - b. Inlet cone shall be a single piece, constructed of **[aluminum][carbon steel][or][stainless steel]**.
 - c. Fasten inlet cone to fan housing using bolts, nuts, and washers to provide a positive and secure attachment that can be removed and replaced in the field.
10. Fan Wheel:
- a. Fan blades with true hollow airfoil shape, continuously welded to backplate or centerplate and wheel cone(s).
 - b. Construct blades of **[aluminum][carbon steel][or][stainless steel]**, reinforced for AMCA fan class.
 - c. Design blades to provide smooth and aerodynamic airflow over all surfaces of blade.
 - d. Construct fan hubs of **[cast aluminum][cast iron, ASTM A48/A48M Class 20A and better][or][stainless steel]**, with integral bracing for extra strength and stiffness.
 - 1) Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.
 - 2) Clean surfaces of castings by blasting, pickling, or other standard method.
 - 3) Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.
 - 4) Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.
 - e. Key and setscrew hubs to shaft for positive attachment.
 - f. Construct wheel backplates or centerplates of **[aluminum][carbon steel][or][stainless steel]**.
 - g. Statically and dynamically balance fan wheel before fan is assembled.
 - h. Select entire rotating assembly so first critical speed is at least **[30]<Insert number>** percent greater than fan design speed and at least **[20]<Insert number>** percent greater than maximum AMCA class speed.
11. Fan Shafts:
- a. Fan shaft shall be one piece, solid **[carbon][or][stainless]** steel, accurately turned, ground, polished, and inspected.
 - b. Polish shafts at the point of bearing contact to comply with bearing manufacturer's recommended tolerances.
 - c. Inspect shafts for straightness after the keyways are cut.
 - d. Coat carbon steel shafts with a rust-inhibitive coating.
12. Fan Shaft Bearings:

- a. Fan bearings shall be foot-mounted type, bolted on a rigid welded steel framework that is integral with, or independent of, the housing.
 - b. Size bearings for L-10 life of at least **[200,000]<Insert value>** hours, a DN factor less than **[200,000]<Insert value>** and a load factor less than **[2,700,000]<Insert value>** at the maximum fan class load limit horsepower, including belt pull.
 - c. Select bearings in accordance with **[ABMA 9][and][or][ABMA 11]**.
 - d. Types:
 - 1) Bearings for Fans with Motor Horsepower up to **[10 hp (7.5 kW)]<Insert size>**: Single-row ball or spherical bearings, self-aligning, grease lubricated, and housed in a pillow block housing.
 - 2) Bearings for Larger-Size Fans: Double-row spherical, self-aligning, grease lubricated, and housed in a horizontally split pillow block housing.
 - e. Grease Fittings:
 - 1) Extend **[copper][or][plastic]** grease lines to an accessible location within sight of bearing for greasing the bearings without removing guards, inlet screens, linkages, and other appurtenances.
 - 2) Terminate bearings and extended grease lines with grease gun fittings.
13. Fan Drives: Fan-drive type, belt or direct, as indicated on Drawings.
- a. Direct Drives:
 - 1) Double-Width, Double-Inlet: Arrangement 7 in accordance with AMCA 99.
 - 2) Single-Width, Single-Inlet: Arrangement **[4][or][5]** in accordance with AMCA 99.
 - 3) For AMCA arrangements 4 and 5, fasten fan wheel directly to motor shaft using a key and setscrew indicated.
 - 4) Construct motor base and pedestal for AMCA arrangement 4 and 7 fans of **[aluminum][carbon steel][stainless steel]** plate.
 - b. Belt Drives:
 - 1) Multiple V-Belt Design:
 - a) Size two belt drives for at least **[2.0]<Insert value>** times the fan motor horsepower.
 - b) Size belt drives with more than two belts, for at least **[1.5]<Insert value>** times the fan motor horsepower.
 - c) Coordinate, with motor manufacturer, the size and location of motor sheave required to satisfy motor L-10 bearing life using motor manufacturer's written instructions.
 - d) Sheave and V-belt selections shall be in accordance with manufacturer's published data.
 - 2) Sheaves:
 - a) Constant-Speed Applications: Fixed or variable sheaves for applications up to **[5 hp (4 kW)]<Insert size>** and fixed sheaves for applications with larger horsepower.
 - b) Variable-Speed Applications: Fixed sheaves.
 - c) Profile machined to Mechanical Power Transmission Association Standards.
 - d) Construct sheaves of high-strength cast iron having a minimum tensile strength of **[25,000 psi (172.4 MPa)]<Insert value>**.
 - e) Sheave rim speeds shall not exceed **[5000 fpm (25.4 m/s)]<Insert value>**.

- f) Sheave side wobble and runout, and eccentricity shall be within Mechanical Power Transmission Association and Rubber Manufacturers Association (RMA) tolerances.
 - g) Balance sheaves to satisfy vibration performance requirements.
 - h) Mount sheaves on the shaft using a taperlock split and keyed bushing or an integral keyed bushing.
 - 3) V-Belts:
 - a) V-belts shall be oil resistant, non-static conducting, and high quality in accordance with RMA standards.
 - b) Classic A, B, C, D, and E, non-cogged, cross sections.
 - c) Multiple belt drives shall be a matched set with belt tolerances in accordance with RMA standards.
 - d) Tension belts in accordance with manufacturer's written instructions.
 - c. Drive Guards: Furnish and factory install fan drive guard(s) for bearing assemblies, rotating shafts, sheaves, belts, couplings, and heat slingers.
 - 1) Arrangement 3 fans do not require guards for bearings on the side opposite the drive.
 - 2) Make provision for motor and fan rpm measurement without removing the guard.
 - 3) Construct the guard of flattened expanded aluminum or steel wrapped around a channel frame, suitably braced to prevent vibration.
 - 4) Paint guards using the same coating as fan, except color shall be safety yellow.
 - 5) Design attachment to fan for easy removal by maintenance personnel using a clamp and latch.
14. Discharge Damper, Counterbalanced Backdraft:
- a. Performance:
 - 1) Velocity and Pressure Rating: Suitable for a face velocity of up to [4000 fpm (20 m/s)]<Insert value> and a static pressure differential of [8.0 inches wg (2000 Pa)]<Insert value>.
 - 2) Leakage: Not to exceed [15 cfm/sq. ft. (0.66 L/s per sq. m)]<Insert value> at a static pressure differential of [1.0 inch wg (250 Pa)]<Insert value>.
 - b. Construction:
 - 1) Frame: Minimum [10-gauge- (3.6-mm-)]<Insert thickness> thick, [galvanized-steel][or][stainless steel] channel frame. Frame to extend beyond blade in open position.
 - 2) Blades: Double-skin airfoil-type parallel blades, constructed of minimum [18-gauge- (1.3-mm-)]<Insert thickness> thick, [galvanized][or][stainless] steel. Include dividers and bracing to form a rigid framework.
 - 3) Axles: [Steel][or][stainless steel]; full length of blade and supported by lubricated ball bearings.
 - c. Mounting:
 - 1) Mount blade axle linkage [in][or][out] of airstream.
 - d. Seals:

- 1) Blades: EPDM.
 - 2) Jambs: Stainless steel, compression-type seals.
15. Discharge Damper, Motorized: Where indicated on Drawings, furnish fans with factory-installed automatic dampers assembled complete in all respects to functions intended.
- a. Performance:
 - 1) Velocity and Pressure Rating: Suitable for a face velocity of at least **[5000 fpm (25.4 m/s)]<Insert value>** and a static pressure differential of **[8.5 inches wg (2125 Pa)]<Insert value>**.
 - 2) Leakage: Not to exceed **[8 cfm/sq. ft. (0.35 L/s per sq. m)]<Insert value>** at a static pressure differential of **[4.0 inches wg (1000 Pa)]<Insert value>**.
 - b. Construction:
 - 1) Frame: Minimum **[10-gauge- (3.6-mm-)]<Insert thickness>** thick, **[galvanized-steel][or][stainless steel]** channel frame. Frame to extend beyond blade in open position.
 - 2) Blades: Double-skin airfoil-type parallel blades, constructed of minimum **[14-gauge- (2.0-mm-)]<Insert thickness>** thick, **[galvanized][or][stainless]** steel. Include dividers and bracing to form a rigid framework.
 - 3) Axles: Each blade with full length axle supported by lubricated ball bearings. Include thrust bearings for dampers mounted in the vertical orientation.
 - c. Mounting:
 - 1) Mount blade axle linkage out of airstream.
 - 2) Mount damper to fan discharge so damper blades are perpendicular to fan shaft.
 - 3) Configure linkage assembly to interface with single electric actuator.
 - d. Seals:
 - 1) Blades: EPDM.
 - 2) Jambs: Stainless steel, compression-type, double seals. Jamb seal shall use an outer standard width seal and a narrow inner seal for maximum compression and minimum leakage when blade is in closed position.
 - e. Damper Electric Actuator:
 - 1) Furnish and factory install an electric actuator for each automated fan discharge damper.
 - 2) Mount actuator on damper frame.
 - 3) Construct interconnecting linkages, lever, and brackets of **[aluminum][carbon steel][or][stainless steel]**. Paint interconnecting linkages, lever, and brackets to match the fan coating.
 - 4) Action, either modulating or two position, as indicated on Drawings.
 - 5) Fail-safe operation (open, closed, or last position) as indicated on Drawings.
 - 6) Size actuators to do the following:
 - a) Shut off against fan maximum pressure on fan curve at design speed.
 - b) Operate the damper with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which damper is subjected.
 - 7) Actuator to include the following:

- a) Indicator and graduated scale on each actuator to show open and closed positions at travel limits.
 - b) Adjustable stops for both maximum and minimum positions.
- 8) Coordinate control interface requirements with external controls to comply with operation indicated.
- 16. Shaft Seals:
 - a. Provide single-width, single-inlet fans with shaft seal(s) where indicated on Drawings.
 - b. Shaft seal(s) shall minimize fan leakage when operating and not operating.
 - c. Construct shaft seal of an aluminum or split stainless steel plate with non-asbestos material fitted under the split metal plate and seated around the shaft.
 - d. Secure split plates to housing using threaded hex-head hardware.
 - e. Shaft seals shall be replaceable from outside the housing without disturbing the shaft or bearings.
 - f. Select shaft seal clearances and materials for operating temperature, pressure, and air quality encountered.
 - g. Shaft seals, including labyrinth, floating bushing, or close clearance annulus, are acceptable alternatives.
- 17. Protective Screens: Factory furnish and install safety screens on unducted fan inlets and discharge openings.
 - a. **[Expanded metal][or][welded wire]** welded to a **[painted carbon steel][or][stainless steel]** frame.
 - b. Screens shall comply with OSHA requirements.
 - c. Screens shall be constructed of **[painted carbon steel][or][stainless steel]**.
 - d. Fasten screens to fan for easy removal by maintenance personnel.
- 18. Piezometer Ring: Mount at fan inlet cone for airflow measurement.
- 19. Welding:
 - a. Use AWS- or ASME-certified welders to weld materials required by application.
 - b. **[Where indicated on Drawings,][All]** welds shall be continuous full-penetration welds.
- 20. Hardware: Hex-head, high-strength **[carbon steel][or][Type 304 or Type 316 stainless steel]**.
- 21. Nameplates:
 - a. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
 - b. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
 - c. Locate nameplates in a highly visible location on motor side of fan.
 - d. Provide the Following Information on Nameplate: **[Engrave][stamp][or][label]**.
 - 1) Manufacturer, address, phone number, and website address.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Manufacturing date.
 - 5) Fan size.
 - 6) Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).
 - 7) Design airflow.
 - 8) Design static pressure.
 - 9) Design fan speed.

- 10) AMCA fan class.
 - 11) **<Insert requirement>.**
22. Special Fan Construction: Where indicated on Drawings, construct individual fans with the following additional features:
- a. Spark-Resistant Construction: Construct fans in accordance with AMCA 99 **[Type A][Type B][Type C]** spark-resistant construction **[where indicated on Drawings]**.
 - b. Heat Slinger: Provide for fans handling air with temperatures exceeding **[150 deg F (65 deg C)]<Insert temperature>.**
 - 1) Cast aluminum, split-design, internally-finned rotor to create a strong circulation of air over the shaft and inboard bearing, and reduce heat conduction along the shaft to bearings.
 - 2) Secure the split halves together using at least two stainless steel bolts and use a setscrew to secure the assembly to fan shaft.
 - c. Corrosion-Resistant Coating:
 - 1) Baked phenolic[, **equal to Heresite's "P-4403 Brown Baked Phenolic Coating"**]**<Insert manufacturer's name and product name or designation>.**
 - 2) Total Dry Film Thickness: **[7]<Insert value>** mils.
 - 3) Application in accordance with manufacturer's written instructions and the following:
 - a) Mist bonding pass and allow to flash off for several minutes, but not long enough to allow film to completely dry.
 - b) Not less than three crisscross multipasses maintaining a wet-appearing film.
 - c) Air dry approximately 45 to 60 minutes with ventilation before applying heat.
 - d) After air dry period has elapsed, raise temperature in recommended increments of 30 minutes until desired temperature is reached.
 - e) Bake intermediate coats at approximately half the final temperature for 10 to 20 minutes.
 - f) Final Bake: **[400 deg F (205 deg C)]<Insert temperature>** for 1-1/2 hours.
 - d. **<Insert requirements>.**
23. Air-Handling Unit Factory Assembly:
- a. Internal Access: Include each fan with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Removal and Replacement: Each fan shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - c. Fan Supports:
 - 1) Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.
 - 2) Construct frame work from aluminum[, **galvanized steel,**], **painted steel,** or stainless steel.

J. Fan Motors:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:



- a. **[Baldor Electric Company]**
 - b. **[Emerson Electric Company]**
 - c. **[Regal Beloit (Genteq)]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **[Toshiba International Corporation]**
 - f. **[US Motors; Nidec Motor Corporation; Nidec Corporation]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Baldor Electric Company]**
 - b. **[Emerson Electric Company]**
 - c. **[Regal Beloit (Genteq)]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **[Toshiba International Corporation]**
 - f. **[US Motors; Nidec Motor Corporation; Nidec Corporation]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain motors from single source from single manufacturer.
4. Standard: Comply with NEMA MG 1 unless more stringent requirements are indicated.
5. Description: NEMA MG 1, **[Design B]<Insert design>**, as required to comply with capacity and torque characteristics; medium-induction motor.
 - a. Performance:
 - 1) Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
 - 2) Efficiency: NEMA Premium Efficiency rating complying with NEMA MG 1.
 - 3) Motor Horsepower: Minimum size as indicated on Drawings. Motor shall operate fan under all conditions indicated without exceeding motor nameplate and without use of motor service factor.
 - 4) Inverter-Duty Rating: Comply with minimum requirements of Class F or Class H insulation, suitable for "inverter-duty" or "drive-duty" applications in accordance with NEMA MG 1. Motor operation through a variable-frequency controller shall not adversely affect the motor performance, operation, useful life, and warranty.
 - 5) Service Factor: **[1.15]<Insert value>**.
 - 6) Temperature Rise: **[Match][One class lower than]<Insert requirements>** insulation rating.
6. Enclosure Type: **[See Drawings for motor enclosure type][ODP][or][TEFC]**.
7. Shaft Grounding System:
 - a. Shaft grounding system to protect bearings from induced voltage.
 - b. Shaft grounding system shall have low drag (less than 0.05 percent of motor horsepower), and shall operate for a minimum of three years without periodic maintenance or adjustments.
 - c. Mounting: External **[or internal]**to motor enclosure.
8. Frame:
 - a. Frames with integrally cast feet unless other requirements of driven equipment require a

- different arrangement.
 - b. Frame, front and back end brackets, and front and back end bearing intercaps constructed of cast iron, ASTM A48/A48M, Class 25 or better.
- 9. Rotor:
 - a. Fabricate rotor frame from die-cast aluminum, copper, or associated alloys.
 - b. Key rotors to motor shaft.
 - c. Rotating assembly shall be dynamically balanced to within limits defined in NEMA MG 1.
 - d. Motors shall have the entire rotating assembly between bearing inner caps coated with a corrosion-resistant coating.
- 10. Stator:
 - a. Copper windings shall be spike resistant to withstand 1600 peak V.
 - b. Entire wound and insulated stator coated with a coating to protect against moisture and corrosion.
- 11. Shaft:
 - a. Solid shaft fabricated of **[carbon][Type 304 stainless][Type 316 stainless][Type 416 stainless]** steel, accurately turned, ground and polished, and inspected for accuracy.
 - b. End of shaft with drilled hole for use in field measurements.
- 12. Bearings:
 - a. Grease-lubricated ball or roller bearings.
 - b. ABMA 11 L-10 motor bearing life of **[100,000]<Insert value>** hours.
 - c. Bearing Lubrication:
 - 1) Factory lubricate motor bearings using a premium moisture-resistant polyurea thickened grease with rust inhibitors suitable for extreme operating temperatures encountered.
 - 2) Coordinate special requirements that may impact lubrication and include appropriate lubrication.
 - d. Grease Fittings:
 - 1) Equip each bearing housing with an easily accessible grease inlet.
 - 2) Fit grease inlets with a grease fitting and protective fitting cap.
 - 3) Equip inlets with an automatic grease relief fitting to prevent excessive greasing.
 - 4) Equip each bearing housing with grease drain and threaded plug.
- 13. Conduit Box:
 - a. Material same as frame.
 - b. For motor frames 365T and below, furnish conduit boxes sized with internal volumes in accordance with NEMA MG 1.
 - c. For motor frames larger than 365T, furnish conduit boxes one size larger than NEMA MG 1.
 - d. Coordinate the location and mounting of conduit box with driven equipment manufacturer.
 - e. Factory mount conduit box on motor.
- 14. Grounding: NRTL-listed clamp-type grounding lug mounted in conduit box.
- 15. Motor Leads:



- a. Non-wicking type, Class F temperature rating or better, and permanently numbered over entire length for identification.
 - b. Lead terminals shall be manufacturer's standard.
- 16. Condensate Drains:
 - a. Motor with drain holes at the lowest point for drainage of condensate.
 - b. Each drain hole with a threaded removable plug.
- 17. TEFC Motor Fans: Corrosion-resistant construction, non-sparking, metallic or non-metallic, bi-directional, and keyed to shaft.
 - a. Motor Fan Cover: **[Steel][Same material as frame]**.
- 18. Hardware: Hex-head, high-strength, zinc-plated carbon steel or stainless steel.
- 19. Lifting Eyebolts: Eyebolt threaded into frame receptacle and design to prevent moisture and other foreign material from entering motor cavity when eyebolt is removed.
- 20. Nameplates:
 - a. Construct nameplates of aluminum or stainless steel and attach to motor frame with aluminum, stainless steel, or brass drive pins.
 - b. Engrave or stamp data on the nameplate.
 - c. At a minimum, include nameplate data in accordance with NEMA MG 1. **[Also include ABMA bearing designation for the drive and opposite end bearing.]**
- 21. Paint: Successfully pass **[500][1000][2000]<Insert value>**-hour salt spray test for corrosion in accordance with ASTM B117.

K. Vibration Isolation:

- 1. General:
 - a. Provide fans inside air-handling units with base and vibration isolation indicated on Drawings.
- 2. Inertia Bases:
 - a. Description: Reinforced structural base designed for concrete infill with integral bolting provisions for fan mounting.
 - b. Design and Performance:
 - 1) Weight of inertia base including concrete infill a minimum of 1.5 times the operating weight of fan.
 - 2) Base thickness not less than 1/12 of longest span.
 - 3) Minimum base thickness is as follows:
 - a) Up to 15 HP (11 kW): **[6 inches (150 mm)]<Insert thickness>**.
 - b) 20 to 50 HP (15 to 37 kW): **[8 inches (200 mm)]<Insert thickness>**.
 - c) 60 to 75 HP (45 to 56 kW): **[10 inches (250 mm)]<Insert thickness>**.
 - d) 100 HP (75 kW) and Larger: **[12 inches (300 mm)]<Insert thickness>**.
 - c. Construction:
 - 1) Base Materials: **[Structural carbon steel, ASTM A36/A36M][structural stainless**

steel, ASTM A276/A276M, Type 304L][or][structural stainless steel, ASTM A276/A276M, Type 316L].

- a) Carbon Steel Finish, Mill Galvanized: Mill-galvanized carbon steel bases with weld-damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.
 - b) Carbon Steel Base Finish: Carbon steel bases cleaned in accordance with SSPC-SP 1, **[SSPC-SP 6/NACE No. 3][SSPC-SP 10/NACE No. 5]** and **[painted][or][hot-dip galvanized]** after fabrication.
- 2) Base Structural Members:
- a) Perimeter Members: **[Channel][I or W beam shapes][or][tube]**.
 - b) Intermediate Members (Spanning Full-Width Base): **[Channel][I or W beam shapes][or][tube]**.
 - c) Cross Members (Spanning Intermediate Members): **[Angle][channel][or][tube]**.
- 3) Reinforcing Bars: Carbon steel, ASTM A615/A615M, sized for a maximum stress of **20,000 psi (138 000 kPa)** when subjected to both static and dynamic loads, and welded in place.
- 4) Floor: Design inertia base with solid floor in bottom for concrete placement after base installation. Seal to prevent leakage or seepage.
- a) Galvanized-Steel Solid Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating, minimum (nominal) **[18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value>** thick.
 - b) Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M; **[Type 304][Type 304L][Type 316][Type 316L]<Insert type>**; No. **[2D][4]<Insert finish>** finish; minimum (nominal) **[18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value>** thick.
- 5) Isolator Brackets: Gusseted, height-saving brackets.
- 6) Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
- d. Air-Handling Unit Factory Assembly: Install fans with inertia bases where indicated on Drawings.
- 1) Coordinate placement of inertia bases with design of air-handling unit structural base. Make provisions for attachment and support.
 - 2) Coordinate inertia base mounting provisions with spring isolators.
3. Spring Isolators:
- a. Performance:
- 1) Deflection: Minimum deflection indicated on Drawings. Use a greater deflection if required to maintain an isolator efficiency of at least **[98]<Insert number>** percent under all operating conditions encountered. Calculate isolator efficiency using actual support conditions considering the rigidity of structure.
 - 2) Laterally stable freestanding open-spring mounting.
 - 3) Spring diameter not less than 0.8 of compressed spring height at rated load and in the installed and operating condition.
 - 4) Reserve travel to solid shall be equal to a minimum of 50 percent of rated deflection and in no case less than 25 percent of rated deflection in an installed and operating

- condition.
 - 5) Ratio of horizontal stiffness to vertical stiffness equal to approximately one.
 - 6) Design and install so that ends of springs remain parallel.
 - 7) Select springs that are non-resonant with equipment related frequencies and natural frequencies of support structure.
 - 8) Springs shall not take a permanent set when compressed to coil bind.
 - 9) Seismic restraints to limit motion under seismic forces to **[1/4 inch (6 mm)]<Insert dimension>**.
- b. Construction:
- 1) Coat springs with PVC or neoprene. Color-code springs to allow positive identification after installation.
 - 2) Construct baseplates, spring retainers, and other components of **[aluminum][galvanized carbon steel][or][stainless steel]**. Etch and paint aluminum components.
 - 3) Use nuts, bolts, and washers and other associated hardware constructed of **[zinc-electroplated carbon steel][or][stainless steel]**.
 - 4) Isolators with integral leveling bolts.
 - 5) Baseplates with holes and isolation grommets for bolting.
 - 6) Bond nominal **[1/4-inch- (6-mm-)]<Insert dimension>** thick, neoprene friction pad to baseplate.
4. Thrust Restraints:
- a. In sets of two or more, thrust restraints shall consist of springs in series with neoprene isolators.
 - b. Coordinate and select deflection of thrust restraints with equipment being restrained.
 - c. Thrust restraints complete with rods and adjustment nuts, plus angle brackets and backing plates for attachment to substrate and equipment being restrained.
5. Elastomeric Grommets:
- a. Elastomeric grommets shall be a combination of neoprene washer and bushing.
 - b. Elastomer shall be 56-durometer maximum.
 - c. Grommets formed to prevent bolts from directly contacting the secured item.
6. Flexible Connections:
- a. Construct flexible connection **[galvanized-steel][or][stainless steel]** edges firmly attached to waterproof and fire-retardant fabric.
 - b. Fabric shall be **[6 inches (150 mm)]<Insert dimension>** wide or more.
 - c. Suitable for operation in extreme temperatures encountered.
 - d. NRTL listed for application and complying with NFPA 90A.
7. Air-Handling Unit Factory Assembly:
- a. Use precompression-type height-saving brackets with isolators having **[2-1/2-inch (65-mm)]<Insert dimension>** deflection or greater, to limit exposed bolt length.
 - b. Install spring isolators plumb and adjust isolators that are not plumb under operating conditions to make plumb.
 - c. Adjust isolators to prevent stress transfer to equipment.
 - d. Verify that installed isolators and mounting systems permit equipment motion in all directions.
 - e. Restrain fans with isolated thrust resistors to limit displacement to **[1/4 inch**

- (6 mm)]<Insert dimension>. Design for maximum lateral thrust the fan can develop.
- f. Adjust or include additional resilient restraints to flexibly limit fan lateral motion to [1/4 inch (6 mm)]<Insert dimension> during startup and operation of equipment.
- g. Anchor restraints to fixed supports having a stiffness greater than the thrust encountered.
- h. Include at least [2-inch (50-mm)]<Insert dimension> operating clearance between fan bases and walking surface of air-handling unit floor. Before startup, clean out foreign matter between bases and equipment to prevent short circuit.
- i. Flexible Connections:
 - 1) Install flexible connections at connections to fans.
 - 2) Install flexible connections in accordance with SMACNA standards and manufacturer's written instructions.
 - 3) Make fabric joints on the flat run, not the corners, with overlap to provide an area sufficient to make a positive seal.
 - 4) Apply adhesive between the fabric layers.
 - 5) Attach connections using screws or bolts.
 - 6) Reinforce fabric if required to keep fabric from collapsing and impacting airflow into fan.

L. Hydronic Coils:

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Aerofin]
 - b. [Coilmaster Corporation]
 - c. [Modine Manufacturing Company]
 - d. [Super Radiator Coils]
 - e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Aerofin]
 - b. [Coilmaster Corporation]
 - c. [Modine Manufacturing Company]
 - d. [Super Radiator Coils]
 - e. <Insert manufacturer's name>
- 3. Sourcing Option: In lieu of sourcing hydronic coils from a specialty coil manufacturer, air-handling unit manufacturer has option to furnish in-house hydronic coils that achieve equal or better performance while complying with other requirements indicated.
- 4. General: Provide air-handling units with hydronic coils where indicated on Drawings.
- 5. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die formed into plate fins.
- 6. Design and Performance:
 - a. Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.
 - b. Air pressure drop, water pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.
 - c. Coils shall be counterflow design, air to fluid. Fluid supply shall enter air leaving side of coil and exit air entering side.

- d. Design coils to be drainable.
 - 1) Coils shall have all circuits drainable when coils are installed in horizontal position and level.
 - 2) Coil supply **[and return]**header shall be furnished with a drain connection at lowest point on header.
 - e. Design coils to be self-venting.
 - 1) Supply connection near bottom of supply header.
 - 2) Return connection near top of return header.
 - 3) Furnish coil return **[and supply]**header with a vent connection at highest point on header.
 - f. Coils supply and return piping connections on same end of coil.
 - g. Coils shall be rated for system operating pressures and temperatures encountered by installation, but not less than **[200 psig (1379 kPa)][300 psig (2069 kPa)]<Insert pressure>**.
 - h. Coil selection criteria, unless otherwise indicated on Drawings, are as follows:
 - 1) Face Velocity: Maximum of **[500 fpm (2.5 m/s)]<Insert value>**.
 - 2) Fluid Tube Velocity (at Design Flow Rate):
 - a) Maximum: **[6 fps (1.8 m/s)]<Insert velocity>**.
 - b) Minimum: **[3 fps (0.9 ms)]<Insert velocity>**.
 - 3) Fluid Header Velocity: Maximum of **[6 fps (1.8 m/s)]<Insert velocity>**.
 - 4) Fin Height: Maximum of **[48 inches (1200 mm)]<Insert dimension>**.
 - 5) Fin Spacing: Maximum of **[12 fins per inch (2.1 mm)]<Insert spacing>**.
 - i. Cooling coils shall have no moisture carryover at design conditions. Install moisture eliminators on discharge face of coil if it is necessary to eliminate moisture carryover.
7. Casing and Tube Sheets:
- a. Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch (13 mm)]<Insert dimension>** beyond face of fins on both entering and leaving sides.
 - b. Casing and Tube Sheet Materials:
 - 1) Cooling Coils: Stainless steel, ASTM A240/A240M or ASTM A480/A480M, **[Type 304L][or][Type 316L]**, No. 2D finish.
 - 2) Heating Coils:
 - a) Stainless steel, ASTM A240/A240M or ASTM A480/A480M, **[Type 304L][or][Type 316L]**, No. 2D finish.
 - b) Galvanized steel, ASTM A653/A653M, **G90 (Z275)** coating.
 - c. Top and Bottom Casings:
 - 1) Flange face minimum of **[1-1/2 inches (68 mm)]<Insert dimension>**; double flange edge for rigidity and ease of removal with secondary flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
 - 2) Thickness:
 - a) Coils with Fin Length of up to 72 Inches (1800 mm): Minimum of **[16 gauge**

- (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - b) Coils with Fin Length Exceeding 72 Inches (1800 mm): Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - d. End Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>.
 - 3) Thickness: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - e. Intermediate Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Space intermediate tube sheets a maximum of [48 inches (1200 mm)]<Insert dimension> o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 - 3) Flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
 - 4) Thickness: Minimum of [16 gauge (1.6 mm)]<Insert thickness> thick.
 - f. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.
 - 8. Fins:
 - a. Materials:
 - 1) Aluminum: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 2) Copper: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 3) 90/10 Cupronickel: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - b. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 - c. Fin Configuration: [Flat face fins without ripples][Flat face or enhanced ripple fins as required by performance].
 - 9. Headers:
 - a. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.
 - b. Tube-to-Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness, to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than 0.12 inch (3 mm).
 - c. Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.
 - d. Drains: Include low point of [supply][supply and return] header with a [NPS 1/2 (DN 13)]<Insert pipe size> drain connection. Extend copper or [red brass][carbon steel][stainless steel]<Insert material> pipe through air-handling unit casing and terminate end with male national pipe thread (MNPT). Pipe shall be threaded on both ends

- e. to facilitate easy field removal and replacement.
Vents: Include high point of [return][supply and return] header with a [NPS 1/2 (DN 13)]<Insert pipe size> vent connection. Extend copper or [red brass][carbon steel][stainless steel]<Insert material> pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - f. Supply and Return Connections:
 - 1) Terminate ends with MNPT.
 - 2) Connections to header shall be either copper tube with brazed ASME B16.18 threaded male adapters or [red brass][carbon steel][stainless steel]<Insert material> pipe with machine-threaded MNPT connections. Pipe shall extend through air-handling unit casing and be threaded on both ends to facilitate easy field removal and replacement.
 - 3) Connections [NPS 2-1/2 (DN 65)]<Insert pipe size> and larger shall have a bronze ASME 16.24 threaded flanges attached to threaded connections to provide for a flanged field connection. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
 - g. Protect openings of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into the coil.
10. Tubes:
- a. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper; [90/10 cupronickel alloy, ASTM B122/B122M].
 - b. Tube Nominal Diameter: 1/2 or 5/8 inch (13 or 16 mm) before expanding, selected to provide performance indicated.
 - c. Tube Nominal Wall Thickness: As required by performance, minimum of [0.020 inch (0.5 mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension> thick.
11. Tube Return Bends: 180-degree bends brazed to tubes; material[, wall thickness,] and nominal diameter to match tubes.
- a. Tube Return Bend Nominal Wall Thickness: As required by performance, minimum of [0.020 inch (0.5 mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension> thick.
12. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.
13. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
14. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:
- a. Baked phenolic.
 - b. Cathodic epoxy.
 - c. Water-based flexible epoxy polymer.
 - d. Water-based synthetic flexible polymer.
 - e. <Insert coating type>.
15. Hardware: Use hex-head bolts, nuts, and washers constructed of [Type 304][or][Type 316] stainless steel.
16. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each

coil, with the following data engraved or embossed:

- a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. Coil fin length.
 - g. Coil fin height.
 - h. Coil weight with fluid/without fluid.
 - i. Coil casing material and thickness.
 - j. Coil fin material and thickness.
 - k. Coil tube material and thickness.
 - l. Coil header material and thickness.
 - m. **<Insert requirements>**.
17. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
18. Air-Handling Unit Factory Assembly:
- a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches (100 mm)]<Insert distance>** beyond exterior face of access panel, and seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Include each coil with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct framework for cooling coils, from aluminum or stainless steel **[structural shapes]**.
 - 3) Construct frame work for heating coils from aluminum **[, galvanized steel,]** or stainless steel **[structural shapes]**.

M. Refrigerant Coils:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Aerofin]**
 - b. **[Coilmaster Corporation]**
 - c. **[Modine Manufacturing Company]**
 - d. **[Super Radiator Coils]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aerofin]**

- b. [Coilmaster Corporation]
 - c. [Modine Manufacturing Company]
 - d. [Super Radiator Coils]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain coils from single source from single manufacturer.
4. General: Provide air-handling units with refrigerant coils where indicated on Drawings.
5. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die formed into plate fins. Coils shall be counterflow circuited and equipped with pressure-type distributors. Distributor tubes shall be of equal length to ensure equal distribution of refrigerant to each circuit.
6. Circuiting: [Face][Row][Interlaced][Interlaced and face control][Indicated on Drawings]<Insert circuiting type>.
7. Performance:
 - a. Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.
 - b. Air pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.
 - c. Rate coils in accordance with AHRI 410 when tested in accordance with ASHRAE 33.
 - d. Coil performance variables and selection procedures shall be in accordance with AHRI 410.
 - e. Coil piping connections on same end of coil.
 - f. Coils shall be rated for system operating flows, pressures, and temperatures encountered by installation.
 - g. Coil selection criteria, unless otherwise indicated on Drawings, are as follows:
 - 1) Face Velocity: Maximum of [500 fpm (2.5 m/s)]<Insert value>.
 - 2) Fin Height: Maximum of [48 inches (1200 mm)]<Insert dimension>.
 - 3) Fin Spacing: Maximum of [12 fins per inch (2.1 mm)]<Insert spacing>.
 - h. Cooling coils shall have no moisture carryover at design conditions. Install moisture eliminators on discharge face of coil if it is necessary to eliminate moisture carryover.
8. Casing and Tube Sheets:
 - a. Depth: Extend coil casing and tube sheets a minimum of [1/2 inch (13 mm)]<Insert dimension> beyond face of fins on both entering and leaving side.
 - b. Casing and Tube Sheet Materials: Stainless steel, ASTM A240/A240M or ASTM A480/A480M, [Type 304L][or][Type 316L], No. 2D finish.
 - c. Top and Bottom Casings:
 - 1) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>; double flange edge for rigidity and ease of removal with secondary flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
 - 2) Thickness: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - d. End Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>.
 - 3) Thickness: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.

- e. Intermediate Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Space intermediate tube sheets a maximum of **[48 inches (1200 mm)]<Insert dimension>** o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 - 3) Flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
 - 4) Thickness: Minimum of **[16 gauge (1.6 mm)]<Insert thickness>** thick.
 - f. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.
9. Fins:
- a. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 - b. Configuration: **[Flat face fins without ripples][Flat face or enhanced ripple fins as required by performance]**.
 - c. Materials:
 - 1) Aluminum: **[0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension>** thick.
 - 2) Copper: **[0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension>** thick.
 - 3) 90/10 Cupronickel: **[0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension>** thick.
10. Headers:
- a. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.
 - b. Tube-to-Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than **0.12 inch (3 mm)**.
 - c. Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.
 - d. Protect openings to prevent entry of dirt into the coil.
11. Tubes:
- a. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper.
 - b. Tube Nominal Diameter: Selected for performance indicated.
 - c. Tube Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch (0.5 mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension>** thick.
12. Tube Return Bends: 180-degree bends brazed to tubes; material, wall thickness, and nominal diameter to match tubes.
13. Brazing: High-temperature brazing alloy with not less than 5 percent silver.
14. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
15. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:

- a. Baked phenolic.
 - b. Cathodic epoxy.
 - c. Water-based flexible epoxy polymer.
 - d. Water-based synthetic flexible polymer.
 - e. **<Insert coating type>**.
16. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304][or][Type 316]** stainless steel.
17. Nameplates: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
- a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. Coil fin length.
 - g. Coil fin height.
 - h. Coil weight.
 - i. Coil casing material and thickness.
 - j. Coil fin material and thickness.
 - k. Coil tube material and thickness.
 - l. Coil header material and thickness.
 - m. **<Insert requirements>**.
18. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with coil material.
19. Air-Handling Unit Factory Assembly:
- a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches (100 mm)]<Insert distance>** beyond exterior face of the access panel, and seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Provide each coil with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct framework for cooling from aluminum or stainless steel **[structural shapes]**.
- N. Steam Coils:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Aerofin]**
 - b. **[Coilmaster Corporation]**
 - c. **[Modine Manufacturing Company]**

- d. **[Super Radiator Coils]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aerofin]**
 - b. **[Coilmaster Corporation]**
 - c. **[Modine Manufacturing Company]**
 - d. **[Super Radiator Coils]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain coils from single source from single manufacturer.
 4. General: Provide air-handling units with refrigerant coils where indicated on Drawings.
 5. Description: Plate fin coils constructed of tubes mechanically expanded into continuous collars that are die formed into plate fins and specially designed for thermal expansion and contraction of the tubes during coil operation.
 - a. Distributing-type steam coils of a tube-in-tube design for uniform steam distribution along the entire length of each tube to ensure a consistent temperature rise across the full coil face and accelerate condensate removal.
 - b. Non-distributing-type steam coils of a single tube design for uniform steam distribution across the entire header and each tube.
 6. Design and Performance:
 - a. Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.
 - b. Air pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.
 - c. Design coils to be drainable.
 - 1) Coils shall have all circuits drainable when coils are installed in horizontal position and level.
 - 2) Coil headers shall be furnished with a drain connection at lowest point on header.
 - d. Vents: Vent connection at highest point on header.
 - e. Coil supply and return piping connections on same end of coil.
 - f. Coils shall be rated for system operating pressures and temperatures encountered by installation, but not less than **<Insert pressure>**.
 - g. Coil selection criteria, unless otherwise indicated on Drawings, are as follows:
 - 1) Face Velocity: Maximum of **[500 fpm (2.5 m/s)]<Insert value>**.
 - 2) Fin Height: Maximum of **[48 inches (1200 mm)]<Insert dimension>**.
 - 3) Fin Spacing: Maximum of **[12 fins per inch (2.1 mm)]<Insert spacing>**.
 7. Casing and Tube Sheets:
 - a. Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch (13 mm)]<Insert dimension>** beyond face of fins on both entering and leaving side.
 - b. Casing and Tube Sheet Materials:
 - 1) Stainless steel, ASTM A240/A240M or ASTM A480/A480M, **[Type 304L][or][Type 316L]**, No. 2D finish.
 - 2) Galvanized steel, ASTM A653/A653M, **G90 (Z275)** coating.

- c. Top and Bottom Casings:
 - 1) Flange face minimum of **[1-1/2 inches (68 mm)]<Insert dimension>**; double flange edge for rigidity and ease of removal with secondary flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
 - 2) Thickness:
 - a) Coils with Fin Length of up to 72 Inches (1800 mm): Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)]** thick.
 - b) Coils with Fin Length Exceeding 72 Inches (1800 mm): Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)]** thick.
 - d. End Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Flange face minimum of **[1-1/2 inches (68 mm)]<Insert dimension>**.
 - 3) Thickness: Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)]** thick.
 - e. Intermediate Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Space intermediate tube sheets a maximum of **[48 inches (1200 mm)]<Insert dimension>** o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 - 3) Flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
 - 4) Thickness: Minimum of **[16 gauge (1.6 mm)]<Insert thickness>** thick.
 - f. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.
8. Fins:
- a. Materials:
 - 1) Aluminum: **[0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension>** thick.
 - 2) Copper: **[0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension>** thick.
 - 3) 90/10 Cupronickel: **[0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension>** thick.
 - b. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 - c. Fin Configuration: **[Flat face fins without ripples][Flat face or enhanced ripple fins as required by performance]**.
9. Headers:
- a. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.
 - b. Tube-to Header Connections: Tube-to-header holes shall intrude inward so landed surface

- area is three times the core tube thickness to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than **0.12 inch (3 mm)**.
- c. Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.
 - d. Drains: Include low point of headers with a **[NPS 1/2 (DN 13)]<Insert pipe size>** drain connection. Extend copper or **[red brass][carbon steel][stainless steel]<Insert material>** pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - e. Vents: Include high point of headers with a **[NPS 1/2 (DN 13)]<Insert pipe size>** vent connection. Extend copper or **[red brass][carbon steel][stainless steel]<Insert material>** pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - f. Supply and Return Connections:
 - 1) Terminate ends with MNPT.
 - 2) Connections to header shall be either copper tube with brazed ASME B16.18 threaded male adapters or **[red brass][carbon steel][stainless steel]<Insert material>** pipe with machine-threaded MNPT connections. Pipe shall extend through air-handling unit casing and be threaded on both ends to facilitate easy field removal and replacement.
 - 3) Connections **[NPS 2-1/2 (DN 65)]<Insert pipe size>** and larger shall have a bronze ASME 16.24 threaded flanges attached to threaded connections to provide for a flanged field connection. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
 - g. Protect openings of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into the coil.
10. Tubes:
- a. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper; **[90/10 cupronickel alloy, ASTM B122/B122M]**.
 - b. Tube Nominal Diameter: **5/8 or 1 inch (16 or 25 mm)** before expanding, selected to provide performance indicated.
 - c. Tube Nominal Wall Thickness: As required by performance, minimum of **[0.035 inch (0.9 mm)][0.049 inch (1.2 mm)]<Insert dimension>** thick.
11. Tube Return Bends: 180-degree bends brazed to tubes; material[, **wall thickness**,] and nominal diameter to match tubes.
- a. Tube Return Bend Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch (0.5 mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension>** thick.
12. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.
13. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
14. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:
- a. Baked phenolic.
 - b. Cathodic epoxy.
 - c. Water-based flexible epoxy polymer.

- d. Water-based synthetic flexible polymer.
 - e. **<Insert coating type>**.
15. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304][or][Type 316]** stainless steel.
16. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
- a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. Coil fin length.
 - g. Coil fin height.
 - h. Coil weight with fluid/without fluid.
 - i. Coil casing material and thickness.
 - j. Coil fin material and thickness.
 - k. Coil tube material and thickness.
 - l. Coil header material and thickness.
 - m. **<Insert requirements>**.
17. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
18. Air-Handling Unit Factory Assembly:
- a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches (100 mm)]<Insert distance>** beyond exterior face of the access panel as seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Include each coil with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct frame work from aluminum[, **galvanized steel,**] or stainless steel[**structural shapes**].
- O. Heating Coils with Integral Face-and-Bypass Dampers:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[LJ Wing; a Mestek Technology, Inc. company]**
 - b. **[Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. [LJ Wing; a Mestek Technology, Inc. company]
 - b. [Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]
 - c. <Insert manufacturer's name>
3. Source Limitations: Obtain coils from single source from single manufacturer.
 4. General: Provide air-handling units with heating coils with integral face-and-bypass dampers where indicated on Drawings.
 5. Description: Horizontal or vertical tube arrangement as indicated on Drawings with integral face-and-bypass dampers and controls installed to control modulating dampers to achieve discharge air temperature set point.
 - a. Each coil consisting of multiple finned heating elements, each with bypasses and interlocking dampers controlled by electric actuators and a discharge airstream thermostat.
 6. Performance:
 - a. Each coil able to maintain constant discharge air temperature regardless of variations in entering-air temperature with constant [steam][and][water] flow through coil.
 - b. Portioning of air across and around the heating element shall result in a uniform temperature within **5 deg F (3 deg C)** of average temperature when measured anywhere across a vertical plane located [24 inches (600 mm)][36 inches (900 mm)] downstream of leaving face of coil.
 7. Casing: [Galvanized steel][or][Type 304 stainless steel], minimum of **16 gauge (1.6 mm)** thick. Standard casing shall be extended if required air-handling unit manufacturer to accommodate installation arrangement inside of the air-handling unit.
 8. Fins: Rectangular shape, constructed of **0.010-inch- (0.25-mm-)** thick aluminum with spacing not closer than **12 fins per inch (2.1 mm)**.
 9. Headers: [Carbon steel][or][copper], of thickness selected by manufacturer for flow, pressure, and temperature encountered; drain connections at low points, vent connections at high points, and supply and return connections located on discharge face of coil.
 - a. Insulation: Insulate headers with mineral-fiber insulation covered by a metal jacket.
 - b. Supply and Return Connections:
 - 1) Terminate ends with MNPT.
 - 2) Connections [NPS 2-1/2 (DN 65)]<Insert pipe size> and larger shall have thread-on flanges. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
 10. Tubes:
 - a. Materials: [Copper][90/10 cupronickel][or][carbon steel].
 - b. Nominal Diameter: **5/8 inch (16 mm)**.
 - c. Nominal Tube Wall Thickness: As required by performance, minimum of [0.035 inch (0.9 mm)][0.049 inch (1.2 mm)] thick.
 11. Dampers: Clamshell design arranged to modulate airflow across or around individual heating elements. Constructed of [galvanized steel][or][Type 304 stainless steel], minimum of **16 gauge (1.6 mm)** thick.
 12. Damper Actuators: [Face][or side] mounted; electric motor for proportional control, failing in last position.
 13. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous

materials.

14. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
15. Coatings: Where indicated on Drawings, coat coil casings and damper assemblies with **[air-dried alkyd enamel][or][baked-epoxy]** corrosion-resistant coating.
16. Hardware: Use hex-head bolts, nuts, and washers constructed of **[zinc-plated carbon steel][or][Type 304 stainless steel]**.
17. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. **<Insert requirements>**.
18. Air-Handling Unit Factory Assembly:
 - a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches (100 mm)]<Insert distance>** beyond exterior face of the access panel as seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Include each coil with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct frame work from aluminum[, **galvanized steel,**] or stainless steel[**structural shapes**].

P. Drain Pans:

1. General:
 - a. Include a drain pan for each cooling[**and heating**] coil and at other locations indicated.
 - b. Continuously weld drain pan seams, joints, and mitered corners to make the assembled drain pan watertight.
 - c. Drain pans shall be located under the entire coil and provide full coil coverage including coil return bends and headers.
 - d. Slope drain pans in multiple directions toward low point drain connection at a uniform slope of at least **[1][2]** percent from high point to low point.
 - e. Include stainless steel blank-offs to prevent air from bypassing around coil.
2. Intermediate Drain Pans:
 - a. Where multiple individual horizontally mounted coils are vertically stacked to make a coil bank, install intermediate drain pans under each stacked coil in the coil bank.
 - b. Material: **[Type 304L][Type 316L][300 series]** stainless steel ASTM A240/A240M or ASTM A480/A480M, a minimum of **[16 gauge (1.6 mm)]<Insert value>** thick.
 - c. Minimum Depth: **[1.0 inch (25 mm)][1.5 inches (38 mm)]<Insert dimension>**.
 - d. Extend drain pan beyond air entering face of coil casing at least **[3 inches**

j. Drain Pipe:

- 1) Air-handling unit manufacturer to connect full size drain pipe to each drain pan connection. Option to use one of following pipe materials:
 - a) Copper tube with threaded male adapter, brazed or soldered to ends.
 - b) Aluminum pipe with threaded MNPT ends
 - c) Stainless steel pipe with threaded MNPT ends.
- 2) Extend drain pipe and terminate **[3 inches (75 mm)]<Insert distance>** beyond exterior face of casing.

Q. Electric Heaters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Brasch Manufacturing Co., Inc]**
 - b. **[Chromalox, Inc.]**
 - c. **[INDEECO]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Brasch Manufacturing Co., Inc]**
 - b. **[Chromalox, Inc.]**
 - c. **[INDEECO]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain heaters from single source from single manufacturer.
4. General:
 - a. Provide air-handling units with electric heaters where indicated on Drawings.
 - b. NRTL listed for zero clearance to combustible surface, regardless of heater capacity.
5. Design and Performance:
 - a. Heaters and installation shall comply with NFPA 70.
 - b. Scheduled capacity (kW) is minimum acceptable.
 - c. Air pressure drop and face velocity are maximum acceptable.
 - d. Rate heaters output capacity at voltage, phase, and hertz indicated on Drawings.
 - e. Arrange capacity control to minimize stratification.
 - f. Equally balance heater electrical load for each step across all three phases.
 - g. Part-Load Operation: Include multiple heaters configured in a **[series][or][parallel]** arrangement with operation staged if required for uninterrupted heater operation over the full range of air-handling unit airflow down to the minimum airflow indicated.
 - 1) Where multiple heaters positioned in a parallel arrangement are required for operation over the full range of air-handling unit airflow, include an automatic isolation damper at the **[inlet][or][discharge]** of inactive heaters to isolate airflow across inactive heaters while other heaters are operating.

6. Heating Elements:
 - a. Open Elements:
 - 1) Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in a frame.
 - 2) Safety Screens: Install safety screens to protect operators from accidentally coming in direct contact with elements.
 - b. Finned Tubular Elements:
 - 1) Coiled resistance wire of 80 percent nickel and 20 percent chromium; center-mounted and surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
 - 2) Finish finned tubular elements with a baked-on aluminum paint, and mount in a frame.
 - 3) Each element individually removable from terminal box.
 - 4) Use threaded stainless steel element terminals and hardware.
7. Frame: **[Galvanized][or][stainless]** steel; include intermediate element support brackets equally spaced at a maximum of **[36 inches (900 mm)]<Insert distance>** o.c. across heater element length.
8. Terminal Box/Control Panel: **[Unit mounted][Remote mounted][Unit or remote mounting arrangement indicated on Drawings]**; with disconnection means and overcurrent protection.
 - a. Enclosure: NEMA 250, **[Type 1][or][Type 12]** enclosure complying with UL 50.
 - b. Full face hinged door **[with lock and key latching device(s)]**.
 - c. Factory insulate base of terminal box to prevent condensation from occurring within box.
 - d. Mount terminal box control panel on exterior surface of air-handling unit casing. Gasket and seal air-handling unit cabinet penetrations.
 - e. Install a laminated elementary wiring diagram on inside face of heater control panel door or in another protected location than visible to service personnel. Wiring diagram shall match installation.
9. Controls:
 - a. Safety Controls: Each heater with following factory-mounted safety controls:
 - 1) Disk-type thermal cutout switch with automatic reset.
 - 2) Primary linear thermal limit cutout switch with automatic reset.
 - 3) Secondary linear thermal limit cutout switch with local manual reset.
 - 4) Airflow Proving Switch: Diaphragm-operated pressure differential type; with pressure range selected to ensure reliable operation throughout full range of air-handling unit airflow down to minimum airflow indicated.
 - b. Staging Control: Magnetic contactors for switching stages of heat except for air-handling units located in occupied spaces, include mercury contactors for switching stages of heat.
 - c. SCR Control: Silicone-controlled rectifier (SCR) for 100 percent stepless capacity control.
 - d. Remote Monitoring and Control: Include control devices necessary to interface with remote-control signals including the following:
 - 1) Heater on/off control.
 - 2) Monitoring heater on/off status.
 - 3) High-temperature alarm.
 - 4) Low-airflow alarm.

- 5) Heater capacity control.
- 6) **<Insert requirement>**.

10. Electrical:

- a. Single-Point Field Power Connection: Install and wire the heater to accommodate a single field electrical connection for electrical power.
- b. Disconnecting Means: Provide each heater with a main electrical power, door mounted and interlocking, and disconnecting means to prevent access into panel, unless switched in the off position.
 - 1) **[Fused disconnect switch][Nonfused disconnect switch][Circuit breaker]** with lockable handle.
 - 2) Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert value> A**.
- c. Factory install and wire branch circuit fusing, or circuit breakers in accordance with NFPA 70.
- d. Pilot Lights: Include labeled pilot lights on face of control panel for the following:
 - 1) Power on.
 - 2) Low-airflow alarm.
 - 3) High-temperature alarm.
 - 4) One for each stage on.
 - 5) **<Insert requirement>**.
- e. Terminations: Wire terminations and field interface terminations to labeled terminal strips.
- f. Control Transformer: Size control circuit transformer for required load, plus 75 VA.
- g. Labeling: Label each electrical device with a laminated phenolic tag.
- h. Use only NRTL labeled electrical components.

11. Nameplate: Include the following data:

- a. Manufacturer name, address, telephone number, and website address.
- b. Manufacturer model number.
- c. Serial number.
- d. Manufacturing date.
- e. Coil identification (indicated on Drawings).
- f. **<Insert requirements>**.

12. Air-Handling Unit Factory Assembly:

- a. Support individual heater assemblies within unit from a structural framework constructed of **[aluminum][galvanized steel][or][stainless steel]**.
- b. Provide each heater assembly with access from **[downstream][and][or][upstream]** sides.
- c. Make provisions in arrangement and installation to mitigate uneven airflow patterns within unit for proper heater operation.

R. Direct-Steam-Injection Panel Distribution Manifold Humidifiers:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. **[Armstrong International, Inc]**
 - b. **[DriSteem]**
 - c. **[Nortec Industries Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[DriSteem]**
 - c. **[Nortec Industries Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain humidifiers from single source from single manufacturer.
4. Description: Prefabricated, direct-steam panel distribution manifold specially designed for steam dispersion in a short distance.
 - a. **[Horizontal][or][vertical]** header with multiple **[vertical][or][horizontal]**, **[nonsteam][steam]**-jacketed tubes.
 - b. **[Nozzles/metered orifices in conjunction with nonsteam-jacketed manifolds][or][punched orifices/no nozzles in conjunction with steam-jacketed manifolds]** spaced evenly along manifold tubes and providing dry and uniform steam distribution.
5. Design and Performance:
 - a. Absorption distance within **[12 inches (300 mm)][18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>**.
 - b. Air Pressure Drop: Less than **0.1 inch wg (25 Pa)** at design velocity.
 - c. Suitable for pressurized steam applications.
6. Headers and Distribution Tubes:
 - a. Material: **[Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
 - b. Insulation: **[Uninsulated][Insulated][Insulated, minimum R-0.5]**.
7. Steam Separator: External separator, or separator/baffles integral to header, to provide condensate-free steam to the distribution tubes.
 - a. Material: **[Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
8. Steam Trap:
 - a. Material: **[Cast iron][Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
 - b. Type: **[Inverted bucket][or][float and thermostatic]**.
 - c. Capacity: Sized for a minimum of **[3]<Insert number>** times the maximum rated condensate flow of humidifier at **[1/2-psig (3.4-kPa)]<Insert value>** differential pressure.
9. Air-Handling Unit Factory Installation:
 - a. Air-handling unit manufacturer shall furnish and install humidifiers with the size and capacities indicated on Drawings.
 - b. Extend humidifier piping through the air-handling unit casing and terminate the connections approximately **[4 inches (100 mm)]<Insert distance>** beyond the exterior face.

- c. Drain Pans: Install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
- d. Provide each humidifier with access for inspection, service, and replacement.
- e. Each humidifier shall be removable for replacement through a removable access panel in the air-handling unit casing or an access door.
- f. Include a freestanding and self-supporting structural **[aluminum or]**stainless steel framework to support each humidifier.

S. Bag Filters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain filters from single source from single manufacturer.
4. Description: Factory-fabricated, dry, extended-surface, unsupported filters with header frames.
5. Performance:
 - a. Filtration Efficiency, ASHRAE 52.2 MERV Rating: **[11][11A][13][13A][14][14A][15][15A][See Drawings].**
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500 fpm (2.5 m/s)**, pressure drop shall not exceed the following:
 - 1) MERV 11 and MERV 11A:
 - a) Depth 12 Inches (300 mm): **0.28 inch wg (70 Pa).**
 - b) Depth 15 Inches (375 mm): **0.26 inch wg (65 Pa).**
 - c) Depth 22 Inches (550 mm): **0.24 inch wg (60 Pa).**
 - d) Depth 30 Inches (750 mm): **0.23 inch wg (58 Pa).**
 - 2) MERV 13 and MERV 13A:
 - a) Depth 12 Inches (300 mm): **0.52 inch wg (130 Pa).**
 - b) Depth 15 Inches (375 mm): **0.48 inch wg (120 Pa).**
 - c) Depth 22 Inches (550 mm): **0.38 inch wg (95 Pa).**
 - d) Depth 30 Inches (750 mm): **0.34 inch wg (85 Pa).**

- 3) MERV 14 and MERV 14A:
 - a) Depth 12 Inches (300 mm): **0.67 inch wg (168 Pa).**
 - b) Depth 15 Inches (375 mm): **0.55 inch wg (138 Pa).**
 - c) Depth 22 Inches (550 mm): **0.45 inch wg (113 Pa).**
 - d) Depth 30 Inches (750 mm): **0.41 inch wg (103 Pa).**
- 4) MERV 15 and MERV 15A:
 - a) Depth 15 Inches (375 mm): **0.81 inch wg (203 Pa).**
 - b) Depth 22 Inches (550 mm): **0.62 inch wg (155 Pa).**
 - c) Depth 30 Inches (750 mm): **0.53 inch wg (133 Pa).**
- d. Manufacturer-Recommended Final Air Pressure Drop: **[1.0 inch wg (250 Pa)]<Insert pressure drop>.**
- e. Pressure Differential without Failure: **[10 inches wg (2500 Pa)]<Insert pressure drop>.**
- f. Temperature Rating: **[158 deg F (70 deg C)]<Insert temperature>.**
6. Certification:
 - a. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
 - b. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
 - c. UL: UL 900 listed.
7. Size:
 - a. Nominal size of individual filters indicated on Drawings:
 - b. Nominal Filter Size:
 - 1) Face: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>.**
 - 2) Depth: **[12 inches (300 mm)][15 inches (375 mm)][22 inches (550 mm)][30 inches (750 mm)]<Insert dimension>.**
 - c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
8. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face:
 - a. Depth 12 Inches (300 mm): **39 sq. ft. (3.6 sq. m).**
 - b. Depth 15 Inches (375 mm): **49 sq. ft. (4.5 sq. m).**
 - c. Depth 22 Inches (550 mm): **71 sq. ft. (6.6 sq. m).**
 - d. Depth 30 Inches (750 mm): **97 sq. ft. (9.0 sq. m).**
9. Construction:
 - a. Media: Glass-fiber material constructed so individual pockets are maintained in tapered form under rated-airflow conditions by flexible internal supports. **[Coat media with an antimicrobial agent.]**
 - 1) Synthetic mesh backing to provide media protection and support.
 - 2) Multiple stitched pockets sealed to eliminate air bypass through stitch points
 - b. Header: Filter face with ABS plastic or corrosion-resistant metal header designed for rigidity and to eliminate racking.
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to header.

T. Cartridge Filters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain filters from single source from single manufacturer.
4. Description: Factory-fabricated, dry, extended-surface, disposable, air filters with media formed in mini-pleats and arranged in a V-shape pattern.
5. Performance:
 - a. Filtration Efficiency, ASHRAE 52.2 MERV Rating: **[11][11A][13][13A][14][14A][16][16A][See Drawings]**.
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500 fpm (2.5 m/s)**, clean filter pressure drop shall not exceed the following:
 - 1) MERV 11 and MERV 11A: **0.21 inch wg (53 Pa)**.
 - 2) MERV 13 and MERV 13A: **0.25 inch wg (63 Pa)**.
 - 3) MERV 14 and MERV 15A: **0.27 inch wg (68 Pa)**.
 - 4) MERV 16 and MERV 16A: **0.60 inch wg (150 Pa)**.
 - d. Manufacturer-Recommended Final Air Pressure Drop: **[1.5 inches wg (375 Pa)]<Insert pressure drop>**.
 - e. Pressure Differential without Failure: **[10 inches wg (2500 Pa)]<Insert pressure drop>**.
 - f. Temperature Rating: **[175 deg F (79 deg C)]<Insert temperature>**.
6. Certification:
 - a. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
 - b. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
 - c. UL: UL 900 listed.
7. Size:
 - a. Nominal size of individual filters indicated on Drawings:
 - b. Nominal Filter Size:

- 1) Face: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
- 2) Depth: **12 inches (300 mm)**.
- c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
8. Filter Media Surface Area: Each filter shall contain at least **[200 sq. ft. (18.6 sq. m)]<Insert area>** for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face.
9. Construction:
 - a. Media: Microfine glass media formed into mini-pleats and arranged in V-shape patterns.
 - b. Media Frame: Plastic or corrosion-resistant metal.
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to frame.
- U. Pleated Panel Filters:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain filters from single source from single manufacturer.
 4. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters.
 5. Performance:
 - a. Filtration Efficiency, ASHRAE 52.2 MERV Rating: **[8][8A][9][9A][See Drawings]**.
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500 fpm (2.5 m/s)**, clean filter pressure drop shall not exceed the following:
 - 1) MERV 8 and MERV 8A:
 - a) Depth 1 Inch (25 mm): **0.23 inch wg (58 Pa)**.
 - b) Depth 2 Inches (50 mm): **0.31 inch wg (78 Pa)**.
 - c) Depth 4 Inches (100 mm): **0.27 inch wg (68 Pa)**.
 - 2) MERV 9 and MERV 9A:
 - a) Depth 2 Inches (50 mm): **0.30 inch wg (75 Pa)**.
 - b) Depth 4 Inches (100 mm): **0.27 inch wg (68 Pa)**.

- d. Manufacturer-Recommended Final Air Pressure Drop: [1.0 inch wg (250 Pa)]<Insert pressure drop>.
- e. Pressure Differential without Failure: [2 inches wg (500 Pa)]<Insert pressure drop>.
- f. Temperature Rating: [200 deg F (93 deg C)]<Insert temperature>.

6. Certification:

- a. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
- b. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
- c. UL: UL 900 listed.

7. Size:

- a. Nominal size of individual filters indicated on Drawings:
- b. Nominal Filter Size:
 - 1) Face: [24 by 24 inches (600 by 600 mm)]<Insert dimensions>.
 - 2) Depth: [1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)].
- c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.

8. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face:

- a. Depth 1 Inch (25 mm): **9.8 sq. ft. (0.9 sq. m).**
- b. Depth 2 Inches (50 mm): **17.3 sq. ft. (1.6 sq. m).**
- c. Depth 4 Inches (100 mm): **27.7 sq. ft. (2.6 sq. m).**

9. Construction:

- a. Media: [**Glass or**][**Cotton and**] synthetic blend of fibers arranged in a series of pleats attached to and supported by a corrosion-resistant welded-wire grid. [**Coat media with an antimicrobial agent.**]
- b. Filter Media Casing: High wet strength (28-point) beverage board that is bonded around the periphery to eliminate air bypass.
 - 1) Diagonal support members across upstream and downstream filter face constructed of same material as casing shall ensure pleat spacing and stability.
- c. Adhesive: Fire-retardant bonding adhesive where bonding media to casing.

V. ASHRAE-Rated Filter Holding Frames:

1. Filter Holding Frames for ASHRAE-Rated Filters:

- a. Fabricate filter holding frames with mitered corners and reinforce frame to maintain a durable, rugged, true square shape.
- b. Construct frames of [**galvanized**][**or**][**stainless**] steel. Use stainless steel frames in applications exposed to corrosive airstreams.
- c. For applications with pre-filter and final filters sharing the same filter holding frame, frames shall be suitable for supporting and holding both pre-filter and final filters in frame with both filters serviceable from upstream (entering air) side.
- d. Frame Depth: At least [**2.75 inches (70 mm)**]<Insert dimension>.
- e. Gaskets: Continuous, suitable for same operating temperature as filters.
- f. Filter Clips: Each filter holding frame with spring clip fasteners at each corner. Spring clips

- g. shall allow filters to be removed and replaced without use of tools. Frames shall be industry-standard size to provide interchangeability of filters from other manufacturers.

2. Air-Handling Unit Factory Installation:

- a. Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.
- b. Furnish filter quantity, size, type, and performance indicated on Drawings.
- c. Install filter frames in a flat vertical position for horizontal airflow.
- d. Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.
- e. Secure individual holding frames together to build a multiple filter bank.
- f. Construct **[aluminum][galvanized-steel][or][stainless steel]** support structure to hold frames and filters.
 - 1) Design support structure for maximum system operating pressures encountered equal to fan shutoff pressure.
 - 2) Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a **[200-lb (890-N)]<Insert value>** lateral force applied at any point on the filter holding frame assembly.

W. Absolute Filters:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain filters from single source from single manufacturer.
- 4. Description: Factory-fabricated, disposable, packaged high-efficiency particulate air filters consisting of an anodized aluminum hold frame with media formed into mini-pleats and arranged in a V-shape pattern.
- 5. Performance:
 - a. Filtration Efficiency:
 - 1) Rating indicated on Drawings.
 - 2) IEST Rating at 0.3-micron Size: **[95][99.99][99.999]<Insert number>** percent.
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500 fpm (2.5 m/s)**, clean filter pressure drop

shall not exceed the following:

- 1) Gasket Seal Filters:
 - a) 95 Percent Efficiency: **0.50 inch wg (125 Pa)**.
 - b) 99.99 Percent Efficiency: **1.0 inch wg (250 Pa)**.
 - c) 99.999 Percent Efficiency: **1.1 inches wg (275 Pa)**.
 - 2) Gel Seal Filters:
 - a) 95 Percent Efficiency: **0.70 inch wg (175 Pa)**.
 - b) 99.99 Percent Efficiency: **0.9 inch wg (225 Pa)**.
 - c) 99.999 Percent Efficiency: **1.1 inches wg (250 Pa)**.
 - d. Manufacturer-Recommended Final Air Pressure Drop: **[2.0 inches wg (500 Pa)]<Insert pressure drop>**.
 - e. Pressure Differential without Failure: **[10 inches wg (2500 Pa)]<Insert pressure drop>**.
 - f. Temperature Rating:
 - 1) Gasket Seal: **[175 deg F (79 deg C)]<Insert temperature>**.
 - 2) Gel Seal: **[155 deg F (68 deg C)]<Insert temperature>**.
6. Certification:
- a. IEST: Tested and rated in accordance with IEST's "Recommended Practice for Testing HEPA Filters."
 - 1) Comply with IEST-RP-CC001.6.
 - 2) Comply with IEST-RP-CC034.
 - b. UL: UL 900 listed.
7. Size:
- a. Nominal Face Size: **[24 by 24 inches (600 by 600 mm)][See Drawings]<Insert size>**.
 - b. Depth: **12 inches (300 mm)**.
 - c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
8. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face:
- a. Gasket Seal:
 - 1) 95 Percent Efficiency: **390 sq. ft. (36.2 sq. m)**.
 - 2) 99.99 Percent Efficiency: **390 sq. ft. (36.2 sq. m)**.
 - 3) 99.999 Percent Efficiency: **431 sq. ft. (40.0 sq. m)**.
 - b. Gel Seal:
 - 1) 95 Percent Efficiency: **401 sq. ft. (37.2 sq. m)**.
 - 2) 99.99 Percent Efficiency: **401 sq. ft. (37.2 sq. m)**.
 - 3) 99.999 Percent Efficiency: **401 sq. ft. (37.2 sq. m)**.
9. Construction for Gasket Seal Filters:

- a. Media: Microfine glass media formed into mini-pleats and arranged in a V-shape pattern.
 - 1) Internal Separators: **[None]<Insert type>**.
 - 2) Media to Filter Frame Seal Material: **[Polyurethane]<Insert material>**.
 - 3) Faceguard Material: **[Aluminum][Stainless steel]<Insert material>**.
 - 4) Faceguard Location: **[None][upstream][and][downstream]**.
 - b. Media-Holding Frame: Anodized aluminum enclosing frame with continuous seamless perimeter **[neoprene]<Insert gasket material>** gasket.
 - 1) Filter Frame to Mounting Frame Seal Location: **[Upstream][Downstream]**.
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to frame.
10. Construction for Gel Seal Filters:
- a. Media: Microfine glass media formed into mini-pleats and arranged in a V-shape pattern.
 - 1) Internal Separators: **[None]<Insert type>**.
 - 2) Media to Filter Frame Seal Material: **[Polyurethane]<Insert material>**.
 - 3) Faceguard Material: **[Aluminum][Stainless steel]<Insert material>**.
 - 4) Faceguard Location: **[None][upstream][and][downstream]**.
 - b. Media-Holding Frame: Anodized aluminum enclosing frame with gel seal track and elastic **[silicone][urethane]<Insert material>** gel sealant.
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to frame.
- X. Absolute Filter Holding Frame Assembly:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain holding frame assembly from absolute filter manufacturer.
 4. Description: Holding frame assembly with access for upstream (front) or downstream (back) filter servicing as indicated, specifically designed for absolute filter banks.
 - a. Gasket Seal: Positive-sealing device to ensure seal between each gasket filter to prevent bypass of unfiltered air. Filter latching mechanism to seat each filter firmly against holding frame surface.
 - b. Gel Seal: Knife-edge to mate to each filter to prevent bypass of unfiltered air. Positive-

locking mechanism for each filter to seat the knife edge into the gel during installation and to remove the filter from the knife edge during filter replacement.

5. Construction:

- a. Each filter bank with a factory-assembled filter holding framework consisting of a framework superstructure, a base, bracing, and removable swing bolt assemblies designed to accommodate the scheduled sizes and configuration of absolute filters.
- b. Framework:
 - 1) Nominal **4 inches (100 mm)**, minimum **11-gauge- (3.1-mm)** thick-, [**galvanized-steel**][or][**stainless steel**] channels or tube.
 - 2) Continuously weld members. After assembly, grind and polish welds to provide a smooth uniform sealing surface.
- c. Base:
 - 1) Continuously weld the framework to a minimum **11-gauge- (3.1-mm-)** thick, [**galvanized-steel**][or][**stainless steel**] base.
- d. Filter Attachment:
 - 1) Equip framework with four swing bolts for each filter.
 - 2) Include each swing bolt with a bearing clamp and hex nut designed for applying a sufficiently uniform sealing pressure against the periphery of each filter.
 - 3) Swing bolts shall be constructed of at least **5/16-inch (8-mm)** [**zinc electroplated**][**galvanized**][or][**stainless**] steel.
 - 4) Hex nuts shall be capable of being torqued to provide at least 50 percent gasket compression.
 - 5) Swing bolt assembly shall provide individual sealing of filters.
- e. Pre-Filter Frames:
 - 1) For filter banks with pre-filters attached on the air entering side of absolute filter, include an ASHRAE-rated filter holding frame.
 - 2) Pre-filter holding frames shall be held in place by swing bolts and allow for installation and removal of pre-filters without disturbing absolute filter seal.

6. Air-Handling Unit Factory Installation:

- a. Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.
- b. Furnish filter quantity, size, type, and performance indicated on Drawings.
- c. Install filter frames in a flat vertical position for horizontal airflow.
- d. Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.
- e. Construct aluminum[, **galvanized-steel**] or stainless steel support structure to hold frames and filters.
 - 1) Design support structure for maximum system operating pressures encountered equal to fan shutoff pressure.
 - 2) Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a [**400-lb (1780-N)**]<Insert value> lateral force applied at any point on the filter holding frame assembly.

Y. Gas-Phase Filters:

1. Gas-Phase Panel-Style Filters:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) **[AAF International]**
- 2) **[Camfil Farr Inc.]**
- 3) **[Flanders Corporation]**
- 4) **[Koch Filter Corporation]**
- 5) **[Purafil, Inc.]**
- 6) **<Insert manufacturer's name>**

- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) **[AAF International]**
- 2) **[Camfil Farr Inc.]**
- 3) **[Flanders Corporation]**
- 4) **[Koch Filter Corporation]**
- 5) **[Purafil, Inc.]**
- 6) **<Insert manufacturer's name>**

- c. Source Limitations: Obtain filters from single source from single manufacturer.
- d. Description: Gas-phase panel filter for installation in a universal ASHRAE-rated filter holding frame.
- e. Performance:

- 1) Initial Air Pressure Drop: Maximum **0.50 inch wg (125 Pa)** at a velocity of **500 fpm (2.5 m/s)**.
- 2) Efficiency: 60 percent ozone-removal efficiency.
- 3) Temperature: **155 deg F (68 deg C)**.

- f. Construction:

- 1) Filters shall be plastic disposable, loose-fill sorbent[**or refillable**].
- 2) Panel shall include perforated face.
- 3) Each panel shall contain at least **12 lb (2.7 kg)** of sorbent.

- g. Nominal Panel Filter Size:

- 1) Face: **24 by 24 inches (600 by 600 mm)**.
- 2) Depth: **2 inches (50 mm)**.

- h. Media:

- 1) Coconut shell activated carbon.
- 2) Activated alumina impregnated with potassium permanganate.
- 3) Blended activated carbon and alumina impregnated with potassium permanganate.
- 4) **<Insert media types for specific applications>**.

- i. Pre-Installation Protection: Package each gas-phase filter in a sealed polyethylene bag to

- prevent unintentional adsorption before installation.
 - j. Gas-Phase Panel-Style Filter Holding Frames: Use ASHRAE-rated filter holding frames.
- 2. Gas-Phase Canister-Style Filters:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Camfil Farr Inc.]**
 - 2) **[Flanders Corporation]**
 - 3) **[Purafil, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Camfil Farr Inc.]**
 - 2) **[Flanders Corporation]**
 - 3) **[Purafil, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain filters from single source from single manufacturer.
 - d. Description: Factory-fabricated, dry, cylindrical canisters containing loose-fill adsorbent media.
 - e. Performance:
 - 1) Initial Air Pressure Drop: **0.60 inch wg (150 Pa)** at a velocity of **500 fpm (2.5 m/s)** when 16 cylinders, **24 inches (600 mm)** long are installed on frames.
 - 2) Efficiency: 95 percent removal efficiency at rated airflow.
 - 3) Temperature:
 - a) Plastic Construction: **105 deg F (41 deg C)**.
 - b) Stainless Steel Construction: **140 deg F (60 deg C)**.
 - f. Canister Construction:
 - 1) Material: **[Disposable ABS HDPE plastic][or][factory-refillable stainless steel]**.
 - 2) Perforations around cylinder surface area for air passage through media.
 - 3) Each canister shall include a mounting assembly with three integral bayonets for mounting to matching cylindrical mounting flange.
 - 4) Gasket seals.
 - 5) Each canister with at least **1.5 lb (2.7 kg)** of sorbent per **6 inches (150 mm)** of canister length.
 - 6) Canister to mounting hardware procedure shall form a mechanical connection with a seal limiting air bypass across canister mounting assembly.
 - g. Filter Size:
 - 1) Nominal Holding Frame Face: **24 by 24 inches (600 by 600 mm)**.
 - 2) Nominal Canister Diameter: **6 inches (150 mm)**.
 - 3) Nominal Canister Length: **[18 inches (450 mm)][24 inches (600 mm)][Length indicated on Drawings]**.

- h. Media:
 - 1) Activated carbon.
 - 2) Impregnated carbon for corrosive and acid gases.
 - 3) Activated alumina impregnated with 4 percent potassium permanganate.
 - 4) Blended activated carbon and activated alumina impregnated with potassium permanganate.
 - 5) **<Insert media types for specific applications>.**
- i. Pre-Installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption before installation.
- j. Canister-Style Gas-Phase Filter Holding Frames:
 - 1) Holding frames shall be **14-gauge (2-mm)** stainless steel with cylindrical sorbent cylinder mounting perforations.
 - 2) Frame shall be assembled from a single piece of metal and welded at junctures to assure a rigid and durable frame assembly.
 - 3) Each frame shall hold 16 canisters.
 - 4) Frame with prepunched mounting holes for cylindrical filter fastener attachment and open airflow paths.
 - 5) Frame designed for front or back loading.
 - 6) Frame surface shall have a flat sealing surface to ensure a secure sorbent canister mount when matched with sorbent cylinders and sealing gasket.
 - 7) Cylinder to mounting hardware procedure shall form a mechanical connection forming a tight seal that minimizes air bypass.

3. Air-Handling Unit Factory Installation:

- a. Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.
- b. Furnish filter quantity, size, type, and performance indicated on Drawings.
- c. Install filter frames in a flat vertical position for horizontal airflow.
- d. Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.
- e. Construct stainless steel support structure to hold frames and filters.
 - 1) Design support structure for weight of gas-phase filters and maximum system operating pressures encountered equal to fan shutoff pressure.
 - 2) Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a **[800-lb (3559-N)]<Insert value>** lateral force applied at any point on the filter holding frame assembly.

Z. Filter Gauges:

- 1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
 - a. Gauge: **[Dwyer Instruments, Inc.; 2000 series Magnahelic filter gauge]<Insert manufacturer's name; product name or designation>.**
 - b. Vent Valves: **[Dwyer Instruments, Inc.; A-310A]<Insert manufacturer's name; product name or designation>.**
 - c. Static Pressure Sensors: **[Dwyer Instruments, Inc.; A-301]<Insert manufacturer's name; product name or designation>.**
 - d. Tubing Compression Fittings: **[Parker; CPI]<Insert manufacturer and product name or designation>.**
- 2. Provide a gauge to indicate pressure differential between entering and leaving side of each filter

bank. Panel filter bank separate from cartridge filter bank.

- a. Where multiple filters share a common frame, include a separate gauge for each filter bank.
 - b. Include a metal spacer constructed of same material as filter frame for one of the filters installed in filter bank to accommodate pressure differential measure across both upstream and downstream filters.
3. Gauge shall have a nominal **4-inch- (100-mm-)** diameter face.
 4. Select range of gauge to be approximately **[twice][three times]<Insert range>** the dirty filter pressure drop.
 5. Provide each gauge with vent valves to allow for re-zeroing the gauge without removing tubing connections.
 6. Include static pressure sensors on entering and leaving side of each filter bank.
 7. Air-Handling Unit Factory Assembly:
 - a. Mount each filter gauge on exterior surface of unit casing near associated filter sections.
 - b. Mount center of gauges **[60 inches (1500 mm)]<Insert distance>** above bottom of air-handling unit structural base.
 - c. Connect static pressure sensors to filter gauges using **[aluminum][copper][or][stainless steel]** tubing and compression type fittings.
 - d. Support tubing at intervals not greater than **[60 inches (1500 mm)]<Insert distance>** o.c.

AA. Automatic Dampers:

1. General: Provide air-handling units with automatic dampers where indicated on Drawings.
 - a. Unless otherwise indicated, use parallel-blade configuration for two-position control, for equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
 - b. Factory assemble multiple damper sections to provide a single damper assembly of size required by application.
 - c. Damper actuator shall be factory installed by damper manufacturer as integral part of damper assembly. Coordinate actuator location and mounting requirements with damper manufacturer.
2. Rectangular Dampers with Aluminum Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**

- 3) [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - 4) [TAMCO (T. A. Morrison & Co. Inc.)]
 - 5) <Insert manufacturer's name>
- c. Source Limitations: Obtain dampers from single source from single manufacturer.
- d. Performance:
- 1) Leakage: AMCA 511, Class 1A. Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
 - 2) Pressure Drop: **0.05 inch wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **[4000 fpm (20 m/s)][6000 fpm (30 m/s)]**.
 - 4) Temperature: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - 6) Damper shall have AMCA seal for both air leakage and air performance.
- e. Construction:
- 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.07 inch (1.8 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.
 - 2) Blades:
 - a) Hollow, airfoil, extruded aluminum.
 - b) Parallel- or opposed-blade configuration as required by application.
 - c) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.07 inch (1.8 mm)** thick.
 - d) Width not to exceed **6 inches (150 mm)**.
 - e) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
 - b) Jambs: Stainless steel, compression type[; **or replaceable, mechanically attached extruded silicone**].
 - 4) Axles: **0.5-inch- (13-mm-)** diameter, **[plated][or][stainless]** steel, mechanically attached to blades.
 - 5) Bearings:
 - a) Molded synthetic or stainless steel sleeve mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
 - 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.

- 7) Additional Corrosion Protection for Corrosive Environments:
 - a) Include anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of **0.0007 inch (0.018 mm)** thick.
 - b) Axles, damper linkage, and hardware shall be constructed of Type 316L grade stainless steel.
- f. Airflow Measurement: Where indicated, include damper assembly with integral airflow monitoring.
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain damper applications from single source from single manufacturer.
 - 4) Performance:
 - a) Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.
 - b) Accuracy shall be within 5 percent of actual flow rate between the range of minimum and design airflow. For applications with a large variation in range between the minimum and design airflow, configure damper sections and flow measurement assembly as required to comply with stated accuracy over the entire modulating range.
 - c) Include a straightening device as part of flow measurement assembly to achieve the specified accuracy with configuration indicated.
 - d) Suitable for operation in untreated and unfiltered air.
 - e) Include temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
 - f) Include automatic zeroing feature.
- g. Airflow Control: Where indicated, provide damper assembly with integral airflow measurement and control.
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
- 3) Source Limitations: Obtain damper assembly from single source from single manufacturer.
- 4) Performance:
- a) A factory-furnished and -calibrated controller shall be programmed, in nonvolatile EPROM, with application-specific airflow set point and range.
 - b) Controller and actuator shall communicate to control the desired airflow.
 - c) Controller shall receive a zero- to 10-V dc input signal and report a zero- to 20-mA output signal that is proportional to airflow.
 - d) Airflow measurement and control range shall be suitable for operation between **150 to 2000 fpm (0.8 to 10 m/s)**.
 - e) Ambient Operating Temperature Range: **Minus 40 to plus 140 deg F (Minus 40 to plus 60 deg C)**.
 - f) Ambient Operating Humidity Range: 5 to 95 percent relative humidity, noncondensing.
 - g) Provide unit with control transformer rated for not less than 85 VA. Include transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.
 - h) Include screw terminals for interface to field wiring.
 - i) Factory mount electronics within a NEMA 250, Type 1 painted steel enclosure.

3. Rectangular Dampers with Insulated Aluminum Blades:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 5) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 5) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain dampers from single source from single manufacturer.
- d. General: Unless otherwise indicated on Drawings, install insulated aluminum blade dampers in applications where dampers close to outdoors.
- e. Performance:

- 1) Leakage: AMCA 511, Class 1A. Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure and shall not exceed **4.9 cfm/sq. ft. (25 L/s per sq. m)** against **4-inch wg (1000-Pa)** differential static pressure at **minus 40 deg F (minus 40 deg C)**.
 - 2) Pressure Drop: **0.1 inch wg (25 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **Minus 100 to plus 185 deg F (Minus 73 to plus 85 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - 6) Damper shall have AMCA seal for both air leakage and air performance.
- f. Construction:
- 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.08 inch (2.0 mm)** thick.
 - b) C-shaped channel with integral flange(s). Mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **4 inches (100 mm)**.
 - d) Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.
 - 2) Blades:
 - a) Hollow shaped, extruded aluminum.
 - b) Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
 - c) Parallel- or opposed-blade configuration as required by application.
 - d) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.08 inch (2.0 mm)** thick.
 - e) Width not to exceed **6 inches (150 mm)**.
 - f) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
 - 3) Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the aluminum extrusions. **[Option to use stainless steel compression-type frame seals.]**
 - 4) Axles: **0.44-inch- (11-mm-)** diameter **[plated][or][stainless]** steel, mechanically attached to blades.
 - 5) Bearings:
 - a) Bearings shall be composed of a celcon inner bearing fixed to axle, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
 - 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.
 - 7) Additional Corrosion Protection for Corrosive Environments:

- a) Include anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of **0.0007 inch (0.018 mm)** thick.
 - b) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.
4. Industrial-Duty Rectangular Dampers with Steel Airfoil Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. Performance:
 - 1) Leakage: Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
 - 2) Pressure Drop: **0.06 inch wg (15 Pa)** at **2000 fpm (10 m/s)** across a **48-by-48-inch (1200-by-1200-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, minimum **10 inches wg (2500 Pa)**.
 - e. Construction:
 - 1) Frame:
 - a) Material: **[Galvanized steel][Type 304 stainless steel][or][Type 316L stainless steel]**, minimum **0.11 inch (2.8 mm)** thick.
 - b) C-shaped channel with mating face minimum of **1 inch (25 mm)**.
 - c) Width not less than **[3 inches (75 mm)][blade width plus 2 inches (50 mm)]**.
 - 2) Blades: Hollow, airfoil shape; constructed of **[galvanized steel][Type 304 stainless steel][Type 316L stainless steel]**, minimum **0.06 inch (1.6 mm)** thick.
 - a) Width not to exceed **[6 inches (150 mm)][8 inches (200 mm)]**.
 - b) Length not to exceed **[36 inches (900 mm)][48 inches (1200 mm)][60 inches (1500 mm)]**.

- 3) Seals:
 - a) Blades: Replaceable, mechanically attached EPDM or extruded silicone.
 - b) Jams: Stainless steel, double compression type.
 - 4) Axles: **0.5- or 0.75-inch- (13- or 19-mm-)** diameter **[plated][Type 304 stainless][or][Type 316 stainless]** steel, mechanically attached to blades **[and continuous from end to end]**.
 - 5) Bearings:
 - a) Stainless steel sleeve type mounted in frame.
 - b) Where blade axles are installed in vertical position, provide thrust bearings.
 - 6) Linkage:
 - a) Face linkage exposed to airstream.
 - b) Constructed of **[plated steel][Type 304 stainless steel][or][Type 316 stainless steel]**.
 - c) Hardware: **[Type 304][or][Type 316]** stainless steel.
5. Damper Actuators:
- a. General:
 - 1) Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which damper is subjected.
 - 2) Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.
 - 3) Total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.
 - 4) Include one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.
 - 5) Avoid use of excessively oversized actuators, which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
 - 6) Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
 - 7) Include mounting hardware and linkages for connecting actuator to damper.
 - 8) Select actuators to fail in desired position in the event of a power failure.
 - 9) Actuator Fail Positions: **[See Drawings.][As indicated below:]**
 - a) Exhaust Air: **[Close][Last position][Open]**.
 - b) Outdoor Air: **[Close][Last position][Open]**.
 - c) Supply Air: **[Close][Last position][Open]**.
 - d) Return Air: **[Close][Last position][Open]**.
 - e) **<Insert system and fail position>**.
 - b. Type: Motor operated, with or without gears, electric and electronic.
 - c. Voltage:
 - 1) **[See Drawings][Voltage selection is delegated to professional designing control system][24 V][120 V]<Insert requirement>**.
 - 2) Actuator shall deliver torque required for continuous uniform movement of controlled

- device from limit to limit when operated at rated voltage.
 - 3) Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.
 - d. Construction:
 - 1) Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
 - 2) 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
 - 3) Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
 - e. Field Adjustment:
 - 1) Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
 - 2) Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when actuator is not powered.
 - f. Two-Position Actuators: Single direction, spring return, or reversing type.
 - g. Modulating Actuators:
 - 1) Capable of stopping at all points across full range, and starting in either direction from any point in range.
 - 2) Control Input Signal:
 - a) Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for **[zero- to 10-][or][2- to 10-]V dc [and][4- to 20-mA]** signals.
 - b) Pulse-Width Modulation (PWM): Actuator drives to a specified position in accordance with a pulse duration (length) of signal from a dry-contact closure, triac sink, or source controller.
 - 3) Programmable Multifunction:
 - a) Control programmable multifunction input, position feedback, and running time shall be factory or field programmable.
 - b) Diagnostic programmable multifunction feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
 - c) Programmable multifunction service data, including at a minimum, number of hours powered, and number of hours in motion.
 - h. Position Feedback:
 - 1) **[Equip][Where indicated, equip]** two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of **[open][and][close]** position.
 - 2) **[Equip][Where indicated, equip]** modulating actuators with a position feedback through **[current][or][voltage]** signal for remote monitoring.
 - 3) Include a position indicator and graduated scale on each actuator indicating open and closed travel limits.
 - i. Fail-Safe:

- 1) Where indicated, provide actuator to fail to an end position.
 - 2) Internal spring return mechanism to drive-controlled device to an end position (open or close) on loss of power.
 - 3) Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.
- j. Integral Overload Protection:
- 1) Provide against overload throughout the entire operating range in both directions.
 - 2) Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.
- k. Damper Attachment:
- 1) Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
 - 2) Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
 - 3) Bolt and set screw method of attachment is acceptable only if included with at least two points of attachment.
- l. Temperature and Humidity:
- 1) Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of [minus 20 to plus 120 deg F (minus 29 to plus 49 deg C)]<Insert temperature range>.
 - 2) Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from [5 to 95]<Insert numbers> percent relative humidity, noncondensing.
- m. Enclosure:
- 1) Suitable for ambient conditions encountered by application.
 - 2) Provide actuator enclosure with a heater and controller where required by application.
 - 3) NEMA 250, Type 2 for all applications except <Insert applications>.
 - 4) NEMA 250, Type 4 or Type 4X for <Insert applications> applications.
- n. Stroke Time: Select operating speed to be compatible with equipment and system operation.
- 1) Operate damper from fully closed to fully open within [15][60][75][90][150]<Insert number> seconds.
 - 2) Operate damper from fully open to fully closed within [15][60][75][90][150]<Insert number> seconds.
 - 3) Move damper to failed position within [5][15][30]<Insert number> seconds.
 - 4) Actuators operating in smoke-control systems shall comply with governing code and NFPA requirements.
- o. Sound:
- 1) Spring Return: 62 dBA.
 - 2) Non-Spring Return: 45 dBA.

BB. Manual Balancing Dampers:

1. General: Air-handling unit manufacturer shall furnish and factory install manual balancing dampers inside air-handling units where indicated on Drawings.
2. Rectangular Manual Balancing Dampers with Aluminum Airfoil Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 3) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 3) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. Performance:
 - 1) Leakage: AMCA 511, Class 1A. Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
 - 2) Pressure Drop: **0.05 inch wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **6000 fpm (30 m/s)**.
 - 4) Temperature: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - 6) Damper shall have AMCA seal for both air leakage and air performance.
 - e. Construction:
 - 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.07 inch (1.8 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.
 - 2) Blades:
 - a) Hollow, airfoil, extruded aluminum.
 - b) Parallel- or opposed-blade configuration as required by application.
 - c) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.07 inch (1.8 mm)** thick.
 - d) Width not to exceed **6 inches (150 mm)**.
 - e) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.

- 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
 - b) Jambs: Stainless steel, compression type.
 - 4) Axles: **0.5-inch- (13-mm-)** diameter **[plated][or][stainless]** steel, mechanically attached to blades.
 - 5) Bearings:
 - a) Molded synthetic or stainless steel sleeve mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
 - 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.
 - 7) Locking Regulator:
 - a) Aluminum or stainless steel standoff with locking regulator mounted to frame in an accessible location for manual adjustment of damper blades.
 - 8) Additional Corrosion Protection for Corrosive Environments:
 - a) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of **0.0007 inch (0.018 mm)** thick.
 - b) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.
3. Industrial-Duty Manual Balancing Dampers with Airfoil Blades:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. Performance:

- 1) Leakage: Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
- 2) Pressure Drop: **0.06 inch wg (15 Pa)** at **2000 fpm (10 m/s)** across a **48-by-48-inch (1200-by-1200-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
- 3) Velocity: Up to **4000 fpm (20 m/s)**.
- 4) Temperature: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)**.
- 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, minimum **10 inches wg (2500 Pa)**.

e. Construction:

- 1) Frame:
 - a) Material: **[Galvanized steel][Type 304 stainless steel][or][Type 316L stainless steel]**, minimum **0.11 inch (2.8 mm)** thick.
 - b) C-shaped channel with mating face minimum of **1 inch (25 mm)**.
 - c) Width not less than **[3 inches (75 mm)][blade width plus 2 inches (50 mm)]**.
- 2) Blades: Hollow, airfoil shape; constructed of **[galvanized steel][Type 304 stainless steel][Type 316L stainless steel]**, minimum **0.06 inch (1.6 mm)** thick.
 - a) Width not to exceed **[6 inches (150 mm)][8 inches (200 mm)]**.
 - b) Length not to exceed **[36 inches (900 mm)][48 inches (1200 mm)][60 inches (1500 mm)]**.
- 3) Seals:
 - a) Blades: Replaceable, mechanically attached EPDM or extruded silicone.
 - b) Jams: Stainless steel, double compression type.
- 4) Axles: **0.5- or 0.75-inch- (13- or 19-mm-)** diameter **[plated][Type 304 stainless][or][Type 316 stainless]** steel, mechanically attached to blades **[and continuous from end to end]**.
- 5) Bearings:
 - a) Stainless steel sleeve type mounted in frame.
 - b) Where blade axles are installed in vertical position, provide thrust bearings.
- 6) Linkage:
 - a) Face linkage exposed to airstream.
 - b) Constructed of **[plated steel][Type 304 stainless steel][or][Type 316 stainless steel]**.
 - c) Hardware: **[Type 304][or][Type 316]** stainless steel.
- 7) Locking Regulator:
 - a) Stainless steel standoff with locking regulator mounted to frame in an accessible location for manual adjustment of damper blades.

CC. Smoke Dampers:

1. General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.

2. Rectangular Smoke Dampers with Aluminum Blades:
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 5) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.
 - e. Performance:
 - 1) Leakage: In accordance with UL 555S, Class 1.
 - 2) Pressure Drop: **0.05 inch wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **250 deg F (121 deg C)**.
 - 5) Pressure Rating: **8.0 inches wg (2000 Pa)**.
 - f. Certification: NRTL listed and labeled in accordance with UL 555S, Class 1.
 - g. Construction:
 - 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.07 inch (1.8 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.
 - 2) Blades:
 - a) Hollow, extruded airfoil shape.
 - b) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.07 inch (1.8 mm)** thick.
 - c) Width not to exceed **6 inches (150 mm)**.
 - d) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.

- 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone.
 - b) Jams: Stainless steel, compression type.
 - 4) Axles: **0.5-inch- (13-mm-)** diameter **[plated][or][stainless]** steel, mechanically attached to blades.
 - 5) Bearings:
 - a) Molded synthetic or stainless steel sleeve mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
 - 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.
3. Rectangular Smoke Dampers with Galvanized-Steel Blades:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.
 - e. Performance:
 - 1) Leakage: In accordance with UL 555S, Class 1.
 - 2) Pressure Drop: **0.07 inch wg (17.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **250 deg F (121 deg C)**.
 - 5) Pressure Rating: **8.0 inches wg (2000 Pa)**.
 - f. Certification: NRTL listed and labeled in accordance with UL 555S, Class 1.
 - g. Construction:
 - 1) Frame:

- a) Material: Galvanized steel, minimum **0.06 inch (1.6 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.
- 2) Blades:
 - a) Hollow, airfoil shape.
 - b) Material: Galvanized steel, minimum **0.06 inch (1.6 mm)** thick.
 - c) Width not to exceed **6 inches (150 mm)**.
 - d) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
- 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone.
 - b) Jams: Stainless steel, compression type.
- 4) Bearings:
 - a) Stainless steel sleeve type mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
- 5) Linkage:
 - a) Concealed in frame.
 - b) Constructed of galvanized steel.
 - c) Hardware: Steel with corrosion-resistant finish.
- h. Actuator:
 - 1) Type: Electric, with electrical characteristics compatible with field power supply.
 - 2) Action: **[See Drawings][modulating][or][two position]**.
 - 3) Control Signal: Individual damper assemblies with multiple actuators shall be factory wired to operate in unison from a single control signal.
 - 4) Fail Position: Closed or open, as indicated on Drawings.
 - 5) Mounting on Damper: External.
 - 6) Quantity: Provide each damper assembly with least number of actuators possible for application.
 - 7) Speed of Response:
 - a) Damper blade operation shall have a controlled movement of at least 5 seconds when travelling from open to close to reduce the potential for damage to duct system and connected equipment.
 - b) Damper closure shall not be instantaneous under any condition.
 - c) Operating time for completion of 90-degree damper travel, from open to close, or from close to open, shall not exceed the more stringent of the following: NFPA references indicated, governing codes, **[15 seconds]<Insert time>**.
- i. Blade Position Switches:
 - 1) Provide damper assemblies with limit switches to provide remote indication of damper blade positions.
 - 2) Provide separate limit switches for remote indication of damper blade open position and damper blade closed position.

- 3) Actuators equipped with remote position indication as an integral part of actuator is acceptable in lieu of separate limit switches only if actuator with integral remote position indication is NRTL listed in accordance with UL 555S.

DD. Duct Silencers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Dynasonics]**
 - b. **[IAC Acoustics]**
 - c. **[Price Industries Limited]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **[Vibro-Acoustics]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dynasonics]**
 - b. **[IAC Acoustics]**
 - c. **[Price Industries Limited]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **[Vibro-Acoustics]**
 - f. **<Insert manufacturer's name>**
3. Duct Silencer Sourcing Option: In lieu of sourcing duct silencers from a specialty duct silencer manufacturer, air-handling unit manufacturer has option to furnish in-house silencers that achieve equal or better performance while complying with other requirements indicated.
 - a. Full-height duct silencers baffles shall span from floor to roof of air-handling unit air tunnel and consist of multiple baffles aligned to fill the entire cross-sectional area of air-handling unit air tunnel. In this alternative, the air-handling unit casing shall serve as the duct silencer casing.
4. General: Air-handling unit manufacturer shall furnish and install duct silencers and associated support structures inside air-handling units where indicated on Drawings.
 - a. Unless otherwise indicated on Drawings, select face area of silencers to fill the entire cross-sectional area of air-handling unit air tunnel.
 - b. Silencer Type: **[Dissipative][Reactive (packless)][Type, either dissipative or reactive (packless), indicated on Drawings]**.
 - c. Factory fabricated.
 - d. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50; ASTM E84.
 - e. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
5. Ratings and Performance:
 - a. Duct silencer manufacturer shall publish performance for dynamic insertion loss (DIL), self-noise power levels, and airflow static pressure loss based on results of performance testing

- indicated.
- b. Duct silencer manufacturer shall test duct silencers in accordance with ASTM E477 in a qualified nationally recognized independent testing laboratory or manufacturer's National Voluntary Lab Accreditation Program-accredited laboratory.
 - 1) Conduct tests with air flowing through duct silencers at not less than three different flow rates and with no airflow.
 - 2) Test methods shall eliminate effects due to end reflection, vibration, flanking transmission, and standing waves in the test chamber.
 - c. DIL is not less than values indicated on Drawings.
 - d. Silencer self-generated noise shall not increase system sound level.
 - e. Static pressure loss not to exceed values indicated on Drawings.
 - f. Structural Performance:
 - 1) Design casing for differential air pressure of **8 inches wg (2000 Pa)** between.
 - 2) Reinforce duct silencer casing to limit deflection to 1/200 of span.
6. Construction: Fabricate rectangular silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for individual unit assemblies.
- a. Casing:
 - 1) Unless otherwise indicated, construct outer casing in accordance with ASHRAE and SMACNA standards for construction of high-pressure rectangular ductwork.
 - 2) Casing seams and joints shall be lock formed and mastic filled, or continuously welded.
 - 3) Materials and Thicknesses, Aluminum, ASTM B 209 (ASTM B209M) Alloy 3003-1114, Smooth Finish:
 - a) Outer Casing: Solid, minimum **[0.040 inch (1.0 mm)][0.063 inch (1.6 mm)]<Insert dimension>** thick.
 - b) Baffles: Perforated, minimum **[0.032 inch (0.8 mm)][0.040 inch (1.0 mm)]<Insert dimension>** thick for sizes through **[24 inches (600 mm)]<Insert dimension>** tall and **[0.040 inch (1.0 mm)][0.063 inch (1.6 mm)]<Insert dimension>** thick for larger sizes.
 - 4) Materials and Thicknesses, Galvanized Steel, ASTM A653/A653M, G60 (Z180) or G90 (Z275) Finish:
 - a) Outer Casing: Solid, minimum **[20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness>** thick.
 - b) Baffles: Perforated, minimum **[24 gauge (0.7 mm)][26 gauge (0.5 mm)]<Insert thickness>** for sizes through **[24 inches (600 mm)]<Insert dimension>** tall and **[20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness>** for larger sizes.
 - 5) Materials and Thicknesses, Stainless Steel, ASTM A240/A240M or ASTM A480/A480M:
 - a) Outer Casing: Solid, minimum **[20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness>** thick.
 - b) Baffles: Perforated, minimum **[24 gauge (0.6 mm)][26 gauge (0.5 mm)]<Insert thickness>** for sizes through **[24 inches (600 mm)]<Insert**

dimension> tall and [20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness> for larger sizes.

- 6) Duct Silencer Material Applications:
- a) Exhaust Air, General: [Aluminum][galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - b) Exhaust Air, Hazardous: [Aluminum][galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - c) Mixed Air: [Aluminum][galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - d) Outdoor Air: [Aluminum][galvanized steel][Type 304L stainless steel][or][Type 304 stainless steel].
 - e) Return Air: [Aluminum][galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - f) Supply Air: [Aluminum][galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - g) <Insert material application>.

b. Dissipative-Type Duct Silencer Fill Materials:

- 1) Inert, vermin-proof, and moisture-proof inorganic mineral or glass fiber of a density sufficient to obtain the acoustic performance indicated. Fiber-free fill materials are an acceptable alternative to fiber fill materials if complying with other requirements.
- 2) Pack fill under not less than [5]<Insert number> percent compression.
- 3) Fill material and coverings shall not exceed the following values when tested in accordance with ASTM E84, NFPA 255, and UL 723:
 - a) Flame-Spread Index: 25.
 - b) Smoke-Developed Index: 50.
 - c) Fuel Contribution: 20.

4) Protective Coverings for Fiber Fill Materials:

- a) Except for silencers used in exhaust applications, completely cover silencer fiber fill materials with a protective covering, such as a tightly woven fiberglass fabric, to prevent particle contamination of airstream without degrading silencer acoustical performance.
- b) For silencers located in airstreams filtered by absolute filters and where located in potentially hazardous exhaust airstreams, enclose the fiber fill material in a polymer sheeting to prevent contaminating airstream without impacting air cleanliness and hygiene. Offset polymer sheeting with honeycomb standoff to prevent polymer sheeting from coming in direct contact with perforated baffles.

- c. Reactive-Type (Packless) Duct Silencer Baffles: Controlled impedance membranes and broadly tuned resonators without absorptive fill material.
- d. Removable Baffles: Design and construct baffles to be easily removable for purposes of cleaning and replacement.

7. Factory Assembly:

- a. Install duct silencers in correct direction with respect to airflow.
- b. Manufacturer's written installation instructions shall not be compromised.
- c. Seal penetrations through duct silencer baffles using a sealant.
- d. Install duct silencers with baffles oriented in the vertical position.

- e. Duct silencer banks consisting of multiple individual duct silencers shall be as follows:
 - 1) Structurally reinforced to support loading and limit deflection to 1/200 of span.
 - 2) Provided with a continuous nosing to cover all joints of adjoining duct silencers. Nosing shall be constructed of same material as duct silencers and attached by friction fit, crimping, or button punch.
 - 3) Fastened together using **[zinc-plated][or][stainless]** steel sheet metal screws that are spaced at not more than **[6 inches (150 mm)]<Insert dimension>** apart, starting at corners.

8. Cleaning:

- a. After assembly, clean duct silencers with HEPA-filtered vacuum machines and then wipe all surfaces with a cleaning agent, using clean rags.

EE. Antimicrobial Ultraviolet (UV) Lamp Systems:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Ultraviolet]**
 - b. **[Steril-Aire, Inc.]**
 - c. **[UV Resources]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Ultraviolet]**
 - b. **[Steril-Aire, Inc.]**
 - c. **[UV Resources]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain lamp systems from single source from single manufacturer.
- 4. Description: UV-C lamp system consisting of power supply, wiring, lamp(s), plug(s), and holder(s) used for ultraviolet germicidal irradiation (UVGI) of cooling coil and condensate drain pan.
 - a. Factory assembled and engineered by a qualified design professional.
- 5. Certification: NRTL listed and labeled in accordance with UL 153, UL 1598, and UL 1995; UL Category Code ABQK; HVAC accessories; air-duct mounted.
- 6. Performance:
 - a. Operating Conditions: Suitable for operation in extreme conditions of the airstream encountered.
 - 1) Relative humidity range not less than 5 to 100 percent.
 - 2) Temperature range not less than **[34 to 158 deg F (1 to 70 deg C)]<Insert temperature range>**.
 - 3) Velocity range not less than **[0 to 600 fpm (0 to 3 m/s)]<Insert velocity range>**.
 - b. Irradiation Intensity:

- 1) Install sufficient quantity of UV-C lamps to provide an average irradiation intensity of [500][1000][2000]<Insert value> microwatts/sq. cm over coil face and exposed surfaces of drain pan.
 - 2) Install sufficient quantity of UVGI fixtures to provide an average irradiation intensity indicated on Drawings.
 - 3) Submit calculations indicating high, low, and average irradiation intensity level across coil face area and drain pan.
 - 4) Take irradiation intensity measurements of factory assembly before air-handling unit shipment to determine results and confirm compliance with requirements. Document and submit measurement results confirming compliance.
 - 5) Intensity calculations shall be based on average output over a lamp life of [9000]<Insert number> hours and account for light output degradation over the lamp life.
- c. Lamp Life: Minimum of [9000]<Insert number> hours.
 - d. Light Output Degradation: Reduction in light output shall not exceed [15][20]<Insert number> percent of initial lamp output over the rated lamp life.
7. Construction:
- a. Lamps:
 - 1) Type: High output, hot cathode; non-ozone producing.
 - 2) Output: UV-C energy, primarily at the 254-nm wavelength with a 360-degree energy distribution.
 - 3) Protective Sleeve: Hermetically sealed to provide protection against lamp breakage and to ensure that lamp contents from a broken lamp are contained.
 - 4) Labeling: Lamp wattage and model number visibly printed on all lamps.
 - 5) Mercury Content: Less than 8 Mg of mercury in each lamp.
 - 6) Lamp Sourcing: Commercially sourced from more than one manufacturer for future replacement. Proprietary lamps available from only one manufacturer are unacceptable.
 - b. Lamp Holders:
 - 1) UV- and moisture-resistant materials designed to connect the lamp to the plug and ensure a watertight connection.
 - 2) Adjustable positioning.
 - c. Wiring Loom: UV-C-resistant jacket materials with internal aluminum/Mylar shield.
 - 1) Conduit: Loom covered with NRTL-listed flexible metal conduit, aluminum, or stainless steel.
 - d. Power Supply: NRTL listed, single phase, 120 or 277 V ac as indicated, with a programmed rapid start.
 - 1) Power Factor: High power factor, Class P, Sound Rated A, Type 1 Outdoor, and with inherent thermal protection and without polychlorinated biphenyl.
 - 2) Wiring Harness: Plug and play.
 - 3) Electrical Connection: Single electrical connection[with service disconnect].
 - e. Enclosures: NEMA 250, [Type 1][Type 4] constructed of [painted carbon steel][stainless steel]<Insert material>.
8. Air-Handling Unit Factory Assembly:

- a. Install UV-C lamp systems in accordance with manufacturer's written instructions.
 - b. Location: Install UV-C lamp system array [**immediately downstream of cooling coil bottom drain pan**][**at locations indicated on Drawings**]**<Insert location within air-handling unit>**.
 - c. UV-C Lamp System Support Assembly: [**Aluminum**][**or**][**300 series grade stainless steel**] framework rigidly attached to air-handling unit casing and adequately braced to provide ridge support of UV-C lamp systems that will not move or damage when leaned on or bumped into by operators.
 - d. Service Access: Lamps shall be easily replaceable from inside the air-handling unit.
 - 1) Install access door(s) with window to access UV light. Treat each window and test to confirm UV emitted through the window is below the threshold limits of NIOSH and ACGIH.
 - 2) If adequate space is unavailable inside air-handling unit, install UV-C lamp systems on a slide out rail to allow lamp replacement from one exterior side of air-handling unit.
 - e. Factory wire UV-C lamp systems internally and terminate at a disconnecting switch on the exterior of the air-handling unit casing.
 - 1) Switch to include a lock-out/tag-out feature.
 - 2) In addition to disconnecting switch, provide each access door accessible to UV-C lamp systems with a position limit switch wired into UV-C lamp systems power circuit to de-energize power to UV-C lamp systems when door is opened.
 - f. Install a caution nameplate at each UV-C lamp systems disconnecting switch that reads: "DANGER, UV LIGHTS - Turn off before entering."
 - g. Protection from UV Damage: Materials in direct or indirect (reflected) contact with UV shall be tested and certified as UV tolerant. Any material not certified shall be completely shielded from UV using a certified UV-tolerant material such as metal. UV tolerance shall be capable of performing intended duty for a minimum of [**20**]**<Insert number>** years.
 - h. Shipping: Remove UV-C lamps after factory testing; package and ship UV-C lamps in protective containers for field installation.
 - 1) Label exterior of enclosures with detailed description of container contents, including air-handling unit designation.
 - 2) Ship UV-C lamps for each air-handling unit in separate containers.
9. UV-C Lamp System Irradiance Monitoring:
- a. Sourcing: Furnished by UV-C lamp system manufacturer with UV-C lamp systems.
 - b. General: UVGI monitoring consisting of sensor(s) and controller to measure and locally display UV output irradiance in [**absolute output (microwatts/sq. cm)**][**and**][**user-defined percentage of relative output**].
 - c. Measurement Range: Suitable for highest measured irradiance encountered by application, but not less than [**10,000**][**20,000**]**<Insert value>** microwatts/sq. cm.
 - d. NIST traceable calibration.
 - e. Remote Monitoring Signal: 4- to 20-mA output signal for remote monitoring.
10. UV-C Lamp System Status Monitoring:
- a. Sourcing: Furnished by UV-C lamp system manufacturer with UV-C lamp systems.
 - b. Monitors operating status of UV-C lamps by measuring change in electrical current.
 - c. On/off status of lamps displayed by LED lights on face of local display unit.
 - d. Remote Monitoring Signal: On/off status relays for remote monitoring.

FF. Heat Wheels:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Innergy Tech, Inc.]**
 - b. **[SEMCO, LLC; part of FlaktGroup]**
 - c. **[Thermotech Enterprises, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Innergy Tech, Inc.]**
 - b. **[SEMCO, LLC; part of FlaktGroup]**
 - c. **[Thermotech Enterprises, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain heat wheels from single source from single manufacturer.
4. Performance:
 - a. Heat wheels shall be engineered by manufacturer to provide a highly reliable, low-maintenance product for use under continuous operation over an extended operating period of not less than **[20][25]<Insert number>** years. Provide supporting documentation if requested to show how features of product design comply with performance indicated.
 - b. Products with ratings that exceed indicated pressure drop, fall short of sensible and latent recovery performance indicated, or transfer contaminants in excess of requirements indicated are unacceptable and should not be submitted for review and approval.
 - c. Fully-assembled and -installed heat wheel shall be suitable for use in air systems that supply air to tenant occupied space and shall comply with NFPA 90A and governing building codes.
5. Testing and Certification:
 - a. Thermal Performance: Certification by a qualified independent testing organization documenting the following:
 - 1) Sensible and latent recovery efficiencies conducted in accordance with ASHRAE 84 with results presented in accordance with ASHRAE 84 and AHRI 1060 (I-P) and AHRI 1061 (SI).
 - 2) Sensible, latent, and pressure loss performance over a range of operating points as required by ASHRAE 84 and specifically for actual airflow conditions required by Project.
 - b. Cross Contamination: Cross-contamination performance reports to validate compliance with requirements indicated.
 - 1) Independent test report shall document desiccant-coated transfer media exhibits **[3][or][4]** Angstrom behavior and does not transfer pollutants typically encountered in indoor air environment having room operations and functions indicated.
 - 2) Testing shall be performed in a test facility complying with ASHRAE 84 for tracer gas testing.
 - 3) Challenge gases used for testing shall include chemicals that represent

contaminates typically encountered and include at least the following: acetaldehyde, methanol, methyl isobutyl ketone, propane, and xylene <Insert contaminate>.

- c. Flame and Smoke: NRTL test report listing flame-spread index and smoke-developed index of media when tested in accordance with ASTM E84 to comply with requirements indicated.
 - d. Microbial Resistance: Test report documenting ability of wheel faces and transfer media to actively limit microbial growth.
 - 1) Testing completed by a qualified research institution or testing laboratory using common live bacterial cultures to document antimicrobial performance with 95 percent mortality effectiveness.
 - e. Corrosion Resistance: Test report summarizing acid-resistance effectiveness of media face coating completed in accordance with ASTM corrosion-test methodologies.
6. Rotors:
- a. Construct rotor media of aluminum base material pre-coated with a desiccant before forming into honeycomb media structure consisting of circular spiral layers.
 - b. Aluminum base material shall be at least [0.0015 inch (0.0381 mm)]<Insert dimension> thick before coating.
 - c. Media layers shall be joined together using adhesive to bond between flat and corrugated media layers.
 - d. Media Coating:
 - 1) Coat media surfaces with a nonmigrating solid adsorbent desiccant layer before forming into the structure to ensure that all surfaces are coated.
 - 2) Desiccant coating shall be inorganic and use a [3][or][4] Angstrom molecular sieve to achieve desired [3][or][4] Angstrom selectivity, excluding contaminants larger than [3][or][4] Angstroms while effectively transferring water vapor.
 - 3) In addition to desiccant coating applied to aluminum substrate, cover two faces of rotor with a two-part polymer coating specifically chosen for chemical resistance and corrosion protection. Coating shall be selected to provide life expectancy indicated when exposed to airstreams encountered.
 - 4) Media exposed to airstream shall exhibit effective antimicrobial action to protect against development and spread of microbial contaminants.
 - 5) Rotor media with applied coatings and adhesive shall have a flame-spread index of [0]<Insert value> and a smoke-developed index of [5]<Insert value> when tested in accordance with ASTM E84.
 - e. Media depth shall be determined by heat wheel manufacturer to achieve performance indicated.
 - f. Media shall not transfer pollutants typically encountered in an indoor air environment having room operations and functions indicated.
 - g. Media shall be cleanable without degrading performance over time.
 - h. Dry particles up to 800 microns shall pass freely through the media.
 - i. Provide segmented rotor media to allow for field installation and replacement of one section at a time without requiring side access. Removal and replacement shall be made while facing rotor media face.
 - j. Rotor media shall be held in place by a rigid structural spoke system made of extruded aluminum.
 - k. Coat exposed surfaces of aluminum spoke system for corrosion protection.
 - l. Rotor structural spoke system shall be designed and manufactured to provide for field installation of media without possibility of media deformation or misfit.

- m. Media shall be secured within structural spoke system by mechanical means, relying on a formed friction fit without use of adhesives or silicone.
 - n. Rotors that cannot be installed in air-handling units as a single complete factory assembly coming from heat wheel manufacturer shall be remotely assembled by trained factory service personnel that are employed by heat wheel manufacturer.
7. Purge Sector:
- a. Factory-set, field-adjustable purge sector designed to limit cross contamination to less than **[0.04]<Insert number>** percent of that of exhaust airstream concentration into supply airstream.
 - b. Factory-set, field-adjustable purge sector designed to eliminate cross contamination of exhaust airstream into supply airstream.
8. Seals:
- a. Maintenance-free "non-contact" type to eliminate wear, excessive drag, and resulting added horsepower required for motor drive system, while still being capable of resisting high-pressure differences.
 - b. Equip rotor with labyrinth seals, which at no time shall make contact with any rotating surface of rotor face.
 - 1) Seals shall be field adjustable and set to within factory-specified tolerances.
 - 2) Provide multipass seals with four labyrinth stages for optimum performance or alternative design with documented test results showing comparable performance.
 - c. Seal shall be secured to housing either by an extruded-aluminum strip with adjustment slots for fastening bolts to the casing frame or by using adjustable clips. Clips shall be made of stainless steel or other noncorrosive material to resist corrosion and possible damage to transfer media.
9. Shafts:
- a. Shaft supporting rotor between bearings shall be one piece, solid steel, accurately turned, ground, polished, and ring gauged for accuracy.
 - b. Machine and polish shaft within bearing contact area to comply with bearing manufacturer's written recommended tolerances.
 - c. Use a dial indicator to inspect shafts for roundness and straightness.
 - d. Coat exposed surfaces of shaft with a corrosion-inhibitive coating.
 - e. Shaft shall be machined to provide a shoulder against bearings for a positive locked position to eliminate any lateral movement of rotor due to axial bearing loads.
10. Bearings:
- a. Support rotor shaft by two pillow block **[tapered roller]**bearings designed for an ABMA 11 L-10 life of at least **[200,000][1,000,000]** hours.
 - b. Bearings shall be maintainable and replaceable without removal of rotor from its casing or media from spoke support system.
 - c. Grease fittings for each bearing shall be easily accessible and within view of bearing.
 - d. Reverse Rotation: Clutch bearing and extended shaft, or equivalent alternative, to prevent reverse rotation and ensure that wheel can only rotate in direction commensurate with effective purge operation.
11. Frame and Housing:
- a. Design frame to limit deflection of rotor due to air pressure loss to less than **[0.03125 inch**

- (0.79375 mm)]<Insert deflection>, [as measured at the outer radius, during maximum rated airflow condition]when exposed to a wheel pressure differential of [25]<Insert number> percent above design conditions.
- b. Construct rigid frame of welded structural [aluminum][galvanized steel][painted steel][or][stainless steel].
 - c. Designed and manufactured in one, two, or more sections as required by application to provide a rigid structure, when completely assembled, capable of supporting rotor.
 - 1) For horizontal airflow applications, support rotor at each end only with no additional support under center.
 - 2) For vertical airflow applications, provide one additional bottom center support.
 - 3) Clearly mark each section of multiple section units for easy installation.
 - d. Construct housing of [galvanized-steel][painted steel][aluminum][or][stainless steel] formed sheets designed to prevent corrosion.
 - e. Housing shall be reinforced as required to provide a solid mounting surface of peripheral and radial seals, to maintain a fixed distance between rotor surface and any housing part.
 - f. There shall be no special requirement to provide air-handling unit casing side access for future rotor removal and service. All rotor service shall be performed from inside air-handling unit at face of rotor.
 - g. Requirements for Painted Frame and Housing:
 - 1) Comply with painting manufacturer's written preparation and application requirements.
 - 2) Treat galvanized steel that is not phosphatized with a phosphate rinse to ensure that paint adheres.
 - 3) Apply rust-inhibiting primer before applying finishing coats.
 - 4) Apply multiple coats to achieve dry film thickness required for protection indicated.
 - 5) Finish coat color to be [manufacturer's standard]<Insert color>.
 - 6) Painted products shall have no deterioration when subjected to the following:
 - a) Salt spray test in accordance with ASTM B117 with 5 percent salt solution fog at 95 deg F for a period of [500][1000][2000]<Insert number> hours.
 - b) Acid-resistance test in accordance with ASTM D3260 with 15-minute exposure to 10 percent hydrochloric acid at room temperature.
12. Motor and Drive Assembly:
- a. Motor Enclosure: Totally enclosed.
 - b. Motor nameplate horsepower shall exceed maximum load of driven assembly.
 - c. Multiple belt-drive assembly shall be automatically tensioned and arranged to eliminate any side-to-side movements and slippage.
 - d. Motor and drive assembly shall be easily accessible and visible for inspection and maintenance.
 - e. Drive assembly, except motor, shall have a life expectancy of [45,000][90,000]<Insert number> hours.
13. Variable-Frequency Controller:
- a. Variable-speed control of rotor through a variable-frequency controller.
 - b. Digital programming with a manual-speed adjustment on the front face of controller.
 - c. Rotor drive system shall allow for a turndown ratio of 80:1 (20 to 0.25 rpm).
 - d. Controller with switchable control either locally on front of controller or remotely by a control system.
 - e. Controller with a motor-rated disconnect switch or circuit breaker having a withstanding

- rating greater than that required by field electrical power system, but not less than [42,000][65,000]<Insert value> A.
- f. Controller mounted in a NEMA 250, [Type 1][Type 4][Type 4X][or][Type 12] enclosure.
14. Rotation Sensor: Proximity-type rotation sensor and target to provide [rotational speed (rpm) analog signal and]wheel stop digital alarm signal for interface to remote-control system.
 15. Monitoring and Control:
 - a. Single-Source Responsibility: Heat wheel manufacturer shall provide a complete monitoring and control package for heat wheel with controller, local display, operator interface, sensors, switches, transmitters, accessories, components, devices, and programming for a complete and operating heat wheel to ensure that responsibility for heat wheel and its operation resides with one source.
 - b. Enclosure:
 - 1) House controller and control devices in a NEMA 250, [Type 1][Type 4][Type 4X][or][Type 12] enclosure.
 - 2) Enclosure with LCD screen to allow viewing and changing parameters.
 - 3) Enclosure with full front face hinged door and lockable handle.
 - 4) Air-handling unit manufacturer shall mount enclosure of outside of air-handling unit casing in vicinity of heat wheel.
 - c. DDC with the following:
 - 1) Conversion of temperature and relative humidity readings into grains, dew point, and enthalpy.
 - 2) Calculation and reporting of real-time unit effectiveness.
 - 3) Calculation and reporting of accumulation of energy (Btu) recovered over time.
 - 4) With user input of energy costs, calculation and accumulation of dollars saved over time.
 - 5) An alarm output if wheel is not rotating and not rotating in correct direction.
 - 6) Programming for integration of enthalpy-based summer-winter change over, frost prevention, and supply temperature control such that they also function correctly as the wheel speed is modulated.
 - 7) Communications and data transfer for remote monitoring and control through ASHRAE 135 (BACnet) interface.
 - 8) Option to achieve conversion and calculations indicated is for heat wheel manufacturer to employ building controls provider, to provide a field-installed DDC with LCD to be mounted directly adjacent to heat wheel manufacturer monitoring and control enclosure.
 - d. Four, field-mounted, high-precision dry-bulb temperature and either wet-bulb temperature or humidity sensors shall be provided by heat wheel manufacturer to air-handling unit manufacturer for factory mounting in accordance with heat wheel manufacturer's written instructions to measure dry-bulb temperature and either wet-bulb temperature or humidity at each of four energy wheel airstreams.
 - 1) Sensors shall be wired to controller or controller expander board located within enclosure.
 - e. Wheel Rotation: Rotation detector module to detect a rotating wheel, and correct direction of rotation[and speed].
 - f. Active Monitoring and Control of Purge: Manufacturer's standard method to ensure that proper purge operation is maintained actively in response to changes in system airflows and pressures that normally occurs with a variable-volume system and where pressure changes appreciably due to filter loading and damper modulation.

16. Air-Handling Unit Factory Assembly:

- a. Internal Access: Provide each heat wheel with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
- b. Removal and Replacement: Each heat wheel shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
- c. Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
- d. Supports for Heat Wheel:
 - 1) Construct a freestanding and self-supporting structural framework to support each heat wheel individually from and independent of adjacent heat wheels.
 - 2) Construct frame work from aluminum **[galvanized-steel]** or stainless steel **[structural shapes]**.
- e. Comply with heat wheel manufacturer's written installation instructions.

GG. Fixed Plate Heat Exchangers:**1. Fixed Plate Sensible Heat Exchangers:**

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Heatex, Inc.]**
 - 2) **[Innergy Tech, Inc.]**
 - 3) **[Klingenburg]**
 - 4) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Heatex, Inc.]**
 - 2) **[Innergy Tech, Inc.]**
 - 3) **[Klingenburg]**
 - 4) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain heat exchangers from single source from single manufacturer.
- d. Description: A device for purpose of transferring only sensible energy from one airstream to another with no moving parts. Design may incorporate parallel, cross-or counterflow construction or a combination of these to achieve the energy transfer.
- e. Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.
 - 1) Maximum Pressure Differential: Suitable for maximum **[6 inches wg (1500 Pa)]<Insert pressure>**.
 - 2) Maximum Temperature: Suitable for maximum **[194 deg F (90 deg C)]<Insert temperature>**.
- f. Casing: **[Aluminum][Galvanized steel]<Insert material>**.
- g. Plates: Evenly spaced, sealed, and arranged for **[counter][cross]** airflow.

- 1) Plate Material: **[Embossed aluminum][Stainless steel][High-density plastic]<Insert material>**.
 - 2) Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for heat exchangers requiring a corrosion-resistant coating.
 - 3) Aluminum Plate Coating: **[None][Epoxy]<Insert coating>**. See Drawings for heat exchangers requiring a corrosion-resistant coating.
2. Fixed Plate Total Heat Exchangers:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[CORE Energy Recovery Solutions]**
 - 2) **[Dais Analytic Corporation]**
 - 3) **[Innergy Tech, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[CORE Energy Recovery Solutions]**
 - 2) **[Dais Analytic Corporation]**
 - 3) **[Innergy Tech, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain heat exchangers from single source from single manufacturer.
 - d. Description: A device for purpose of transferring total energy (sensible and latent) from one airstream to another with no moving parts. Design may incorporate parallel, counterflow construction to achieve the energy transfer.
 - e. Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.
 - 1) Maximum Pressure Differential: Suitable for maximum **[6 inches wg (1500 Pa)]<Insert pressure>**.
 - 2) Maximum Temperature: Suitable for maximum **[194 deg F (90 deg C)]<Insert temperature>**.
 - f. Casing: **[Aluminum][Galvanized steel]<Insert material>**.
 - g. Plates: Evenly spaced, sealed, and arranged for counter airflow.
 - 1) Plate Material and Coating: Chemically treated paper, or polymer on **[aluminum]<Insert material>**, with selective hydroscopicity, moisture permeability, and gas barrier properties.
3. Air-Handling Unit Factory Assembly:
- a. Internal Access: Provide each fixed plate heat exchanger with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Removal and Replacement: Each fixed plate heat exchanger shall be independently removable and replaceable through a removable access panel or door installed in air-handling unit casing.
 - c. Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.

- d. Supports for Fixed Plate Heat Exchanger:
 - 1) Construct a freestanding and self-supporting structural framework to support heat exchangers.
 - 2) Construct frame work from aluminum[, **galvanized-steel,**] or stainless steel[**structural shapes**].
- e. Comply with fixed plate heat exchanger manufacturer's written installation instructions.

HH. Heat Pipe Heat Exchangers:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Engineered Air]**
 - b. **[Heat Pipe Technology, Inc.]**
 - c. **[Innergy Tech, Inc.]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Engineered Air]**
 - b. **[Heat Pipe Technology, Inc.]**
 - c. **[Innergy Tech, Inc.]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain heat exchangers from single source from single manufacturer.
- 4. Description: Air-to-air energy recovery heat exchanger employing tubes charged with a fluid for purpose of transferring sensible energy from one airstream to another through the vaporization of fluid.
- 5. Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.
- 6. Certification: Rated[, **listed and labeled**] in accordance with AHRI 1060 (I-P) and AHRI 1061 (SI).**[NRTL listed in accordance with UL 207.]**
- 7. Casing and Tube Sheets: **[Galvanized-steel][or][stainless steel]** flanged casing minimum **[16 gauge (1.6 mm)]<Insert thickness>** thick, with airtight **[single][double][foam-filled double]** partition between exhaust and supply airstreams.
- 8. Fluid in Sealed Tubes: Selected by heat pipe heat exchanger manufacturer and classified as Safety Group A1 in accordance with ASHRAE 34.
- 9. Tubes:
 - a. Tube Diameter: Selected by heat pipe heat exchanger manufacturer; not less than nominal **1/2 inch (13 mm)** and not more than nominal **1 inch (25 mm)** in diameter.
 - b. Tube Material: **[Aluminum][or][copper]<Insert material>**; minimum thickness required for fluid pressure and temperature encountered.
 - c. Number of Tube Rows: As required by performance; not to exceed **[8]<Insert number>**.
- 10. Fins: **[Aluminum][or][copper]<Insert material>**.
 - a. Fin Configuration: **[Extruded][plate][or][spiral]**.
 - b. Fin Spacing: As required by performance; not to exceed **12 fins per inch (2.1 mm)**.

- c. Fin and Tube Bond: **[Mechanical expanded into collared fins and tube sheets][Silver brazed]**.
- 11. Coating: **[None][Flexible epoxy polymer E-coating][Baked phenolic]<Insert coating>**; apply to supply and exhaust.
- 12. Control:
 - a. Integral plenum containing heat pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.
 - b. Pivot center of bottom of heat pipe coil on shaft and bearings to tilt coil. Include tilt controls with electronic controller, electric actuator and linkage, thermostats, sensors, and polyester-fabric-coated flexible connector for automatic supply temperature regulation, summer/winter changeover, and frost protection.
- 13. Air-Handling Unit Factory Assembly:
 - a. Internal Access: Provide each heat pipe heat exchanger with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Removal and Replacement: Each heat pipe heat exchanger shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - c. Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
 - d. Supports for Heat Pipe Heat Exchanger:
 - 1) Construct a freestanding and self-supporting structural framework to support each heat pipe heat exchanger individually from and independent of adjacent heat pipe heat exchangers.
 - 2) Construct frame work from aluminum[, **galvanized-steel,**] or stainless steel **[structural shapes]**.
 - e. Comply with heat pipe heat exchanger manufacturer's written installation instructions.

II. Air Blenders:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Blender Products, Inc.]**
 - b. **[Kees, Inc]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Blender Products, Inc.]**
 - b. **[Kees, Inc]**
 - c. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain blenders from single source from single manufacturer.
- 4. Description: Static air mixing devices fabricated in assemblies consisting of multidirectional vanes that are designed to reduce stratification of multiple mixed airstreams and improve uniformity of the air tunnel velocity profile located downstream of air mixer.

5. Performance:
 - a. Certification: Documented performance verified by tests performed by an independent agency **[or][factory tests witnessed by a professional engineer that is not a company employee]**.
 - b. Mixing: Uniform mixed airstream within **[6 deg F (3 deg C)]<Insert temperature>** of the theoretical average temperature of two or more airstreams.
 - c. Indicated on Drawings.
6. Construction:
 - a. Configuration: Indicated on Drawings.
 - b. Material: **[Aluminum][galvanized steel][Type 304 stainless steel][or][Type 316 stainless steel]**.
 - c. Thickness: **[0.080 inch (2.06 mm)][0.125 inch (3.18 mm)]<Insert dimension>**.
 - d. Attachment: Integral mounting flange for attachment to mounting substrate.
 - e. Welding: Stitch or continuous welds. Filler metals matched to welded materials.
 - f. Hardware: **[Stainless][Zinc-plated carbon]** steel.
 - g. OEM Factory Assembly: Single-piece assembly for sizes through **96 inches (2400 mm)**. For larger sizes, air mixers shall be fabricated in two pieces, bolted together to ensure proper fit and alignment and then disassembled for shipment.
 - h. Finish: **[Anodized]<Insert requirements>**.
7. Air-Handling Unit Factory Assembly:
 - a. Internal Access: Provide each air mixer with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Install air mixer assemblies in an internal separating wall reinforced to limit deflection to **[L/200]<Insert value>** when subjected to a horizontal force of **[200 lb (900 N)]<Insert value>** at any point on the air mixer assembly.
 - c. Blank-off and seal assembly to prevent leakage and air bypass around air mixer.
 - d. Operating Clearance: Maintain upstream and downstream operating clearances in accordance with manufacturer's written installation requirements.

JJ. Air-Handling Unit Factory Drain Piping and Piping Insulation:

1. General:
 - a. Air-handling unit manufacturer to factory install piping inside air-handling units.
 - b. If more than one material is listed, material selection is by air-handling unit manufacturer.
2. Aluminum Piping:
 - a. Pipe: Aluminum ASTM B241/B241M, Grade 1061, Temper T6, seamless longitudinal joints with beveled or plain ends; and wall thickness as indicated under applications.
 - b. Fittings: Cast aluminum, ASTM B26/B26M, Grade 356, Temper T6, ASME B16.1 Class 150; threaded ends.
 - c. Flanges: Cast aluminum, ASTM B26/B26M, Grade 356, Temper T6, ASME B16.1, Class 150 including bolts, nuts, washers, and gaskets of the following end connections and facings:
 - 1) Threaded end connections for threaded joints, welding-neck with butt-joint for welded joints, and blinds for use with flanged joints requiring close-off.
 - d. Unions: Cast-aluminum, ASTM B26/B26M, Grade 356, Temper T6, hexagonal-stock body;

female NPT threaded ends.

3. Copper Tubing:

- a. Tubing: Drawn temper, **[ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88M, Type C)][or][Type DWV in accordance with ASTM B306]**.
- b. Fittings: Wrought-copper and copper-alloy, ASME B16.22, pressure fittings.
- c. Unions: Cast-copper-alloy, MSS SP-123, hexagonal-stock body; female NPT threaded ends
- d. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux in accordance with ASTM B813.

4. Stainless Steel Piping:

- a. Pipe: ASME B36.19/ASME B36.19M, stainless steel ASTM A312/A312M, with beveled or plain ends; seamless **[or welded]** longitudinal joints, Grade TP316L, and wall thickness as indicated under applications.
- b. Fittings, Threaded: MSS SP-114, Class 150, stainless steel ASTM A351/A351M, Grade CF8M.
- c. Fittings, Welded: ASME B16.9, stainless steel ASTM A403/A403M, Grade WP316L, seamless, wall thickness to match adjoining pipe.
- d. Flanges: Stainless steel ASTM A182/A182M, Grade F316L, ASME B16.5, Class 150 including bolts, nuts, washers, and gaskets of the following material group, end connections, and facings:
 - 1) Material Group: 2.2.
 - 2) Threaded end connections for threaded joints, welding-neck with butt-joint for welded joints, and blinds for use with flanged joints requiring close-off.
- e. Unions: MSS SP-114, Class 150, stainless steel ASTM A351/A351M, Grade CF8M; female NPT threaded ends.

5. Floor Drain Piping:

- a. **[Schedule 40]<Insert pipe schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or][copper tube with soldered threaded male adapters]**.
- b. Factory install a dedicated drain pipe for each floor drain and extend pipe to access side of air-handling unit.
 - 1) Terminate pipe with a threaded pipe cap **[3 inches (75 mm)]<Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.
 - 2) Pipe size to match size of floor drain connection.

6. Fan Drain Piping:

- a. **[Schedule 40]<Insert pipe Schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or][copper tube with soldered threaded male adapters]**.
- b. Factory install a dedicated drain pipe for each housed centrifugal fan with a drain connection and extend pipe to access side of air-handling unit.
 - 1) Terminate pipe with a threaded pipe cap **[3 inches (75 mm)]<Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.
 - 2) Install a twin sphere **[EPDM][or][neoprene]** pipe connector in the pipe between the fan connection and the pipe penetration through the air-handling unit casing.

- 3) Pipe size to match size of fan drain connection.
- 4) Install a threaded union or thread-on flange in drain pipe at connection to fan.

7. Drain Pan Piping:

- a. **[Schedule 40]<Insert pipe schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or][copper tube with soldered threaded male adapters]**.
- b. Factory install drain piping for drain pan(s). Install a dedicated drain pipe for each drain pan serving different air-handling unit internal components. Where multiple drain pans serve like components interconnect drain piping to a single drain pipe for field connection.
 - 1) Where interconnecting cooling coil condensate drain pans from upstream and downstream sides of cooling coil, provide pipe with a water seal trap configured to prevent air bypass.
 - 2) Terminate pipe with a threaded pipe cap **[3 inches (75 mm)]<Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.
 - 3) Drain pipe size to match size of drain pan connection.

8. Piping Insulation:

- a. Factory insulate bottom cooling coil drain pan pipe with **[1-inch- (25-mm-)]<Insert dimension>** thick, flexible elastomeric insulation where pipe is located under and outside of the air-handling unit casing but within the air-handling unit base.
- b. Factory insulate steam and steam condensate piping located inside of air-handling with **[2-inch- (25-mm-)]<Insert dimension>** thick, preformed mineral-fiber pipe insulation.
- c. Cover pipe insulation with a factory-applied aluminum or stainless steel jacket.

KK. Drains:

1. Floor Drains:

- a. Drain Body: Fabricate floor drain body of **NPS 4 (DN 100)** or larger aluminum or stainless pipe and weld a plate of same material to the bottom. Option to fabricate an aluminum or stainless steel rectangular box drain at least **4 by 4 inches (100 by 100 mm)** of material at least **0.1 inch (3 mm)** thick.
- b. Drain Connection: Weld a nominal **[NPS 2 (DN 50)]<Insert pipe size>** half coupling in side of drain body located within **1 inch (25 mm)** from bottom.
- c. Drain Cover: Perforated plate, at least **0.1 inch (3 mm)** thick, or grating, fabricated from aluminum or stainless steel. Drain cover shall be supported and secured in place by drain body, but not fastened to drain body with fasteners.
- d. Fluid Seal: **[Seal][Weld]** floor drain body to air-handling unit floor for a watertight installation.
- e. Mounting: Recess floor drain body into structural base. Top of floor drain to be slightly recessed below air-handling unit finished floor for unobstructed gravity flow from floor into drain.
- f. Application:
 - 1) Install floor drains in air-handling unit floors at locations indicated on Drawings.
 - 2) Install floor drains in air-handling unit floors of all sections.
 - 3) Install floor drains in air-handling unit floors of **[coil][coil and humidifier][coil, heat wheel, heat exchanger, humidifier][potentially wet]<Insert floor drain locations>** sections and associated access sections.

LL. Factory-Assembled Electrical:

1. Factory install **[UV-C and switches,][service light fixtures and switches,][and][receptacles]** for each air-handling unit.
 - a. Locate in a convenient and field-accessible location.
 - b. Installation shall comply with NFPA 70.
 - c. Wire, Conduit, and Enclosures:
 - 1) Minimum Conduit Size: **[3/4 inch (20 mm)]<Insert dimension>**.
 - 2) Materials: **[Metal, with a corrosion-resistant finish][Aluminum or stainless steel][Stainless steel]**.
 - 3) Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware **[constructed of stainless steel]**.
 - 4) Conduit: Locate conduit inside the air-handling unit casing. Conduit installed on exterior of air-handling unit casing is unacceptable.
 - 5) Wire:
 - a) Copper, rated for 600 V, solid wire for size **[No. 10 AWG]<Insert wire size>** and smaller and stranded wire for larger sizes.
 - b) Minimum Wire Size: **[No. 12 AWG]<Insert wire size>**.
 - c) Each circuit shall have a ground wire.
 - d) Install wire in conduit.
 - 6) Boxes, Conduit Outlet Bodies, and Enclosures:
 - a) Located in Airstream: NEMA 250, **[Type 4][Type 4X][or][Type 12]<Insert type>**.
 - b) Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 1][or][Type 12]<Insert type>**.
 - 7) Seals: Seal pathways to prevent air leakage between air-handling unit exterior and interior, and between internal component sections.
 - 8) UV-C Lamp System Applications: Wire all UV-C lamp systems located in the same air tunnel to a single circuit.
 - 9) Service Lighting Applications:
 - a) Provide quantity of 20-A branch circuits required to power service light fixtures.
 - b) For air-handling units consisting of multiple stacked tiers, provide separate circuits for top and bottom tiers of air-handling units.
 - c) Factory install a **[main disconnect switch][field power junction box]** for interfacing air-handling power for service lighting with single-point field power wiring connection.
 - 10) Receptacle Applications:
 - a) For air-handling units consisting of multiple stacked tiers, provide separate circuits for top and bottom tiers of air-handling units.
 - b) Factory wire receptacles to a **[main disconnect switch][field power junction box]** for interfacing air-handling power for receptacles with a single-point field power wiring connection.
2. Main Disconnect Switches: Factory-install main disconnect switch mounted on air-handling unit casing exterior for interface of factory power wiring with field power wiring.
 - a. Specification Grade: "Heavy duty type"; "quick-make," "quick-break" construction.
 - b. Three pole, **[fused][or][nonfused]**.

- c. 600 V rated.
 - d. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than [42,000][65,000]<Insert value> A.
 - e. Enclosure: NEMA 250, [Type 1][Type 12]<Insert Type>.
 - f. Operating handle shall be of box-mounted type that directly drives switch mechanism.
 - g. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
 - h. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
 - i. Include a solid neutral as required by authorities having jurisdiction.
 - j. Disconnect switch shall have a ground lug for ground wire termination.
 - k. Operating handle shall be lockable in open position.
 - l. Horsepower rated.
 - m. Feed through or double lugged.
3. Field Power Junction Box: Factory-install junction box with internal wire terminal block mounted on air-handling unit casing exterior for interface of factory power wiring with field power wiring.
 4. Service Light Fixtures:
 - a. Fluorescent Luminaires:
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation>.
 - 2) Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - 3) High-impact, UV-stabilized fiberglass-reinforced polyester housing, high-impact acrylic lens.
 - 4) Two, cool white, T [5][5HO][8][8HO] lamps, and an electronic ballast.
 - b. LED Luminaires:
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation>.
 - 2) Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - 3) High-impact, UV-stabilized fiberglass housing and acrylic lens.
 - 4) Light Color: [3500][4000][5000] K.
 - 5) Light Output: [2000][3000][4000] lumens.
 - 6) Driver: 1 percent dimming.
 - c. Vaportight Fixtures:
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation>.
 - 2) Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - 3) Cast aluminum housing and guard with heat-resistant, tempered, clear glass globe.
 - 4) Incandescent Lamps: [150][200][300] W.
 - 5) LED A21 Series Lamps:
 - a) Light Color: [3000][5000] K.
 - b) Light Output: [1700]<Insert value> lumens.

- d. Application:
 - 1) Provide service light fixtures where indicated on Drawings.
 - 2) Provide one service light fixture in each accessible section of air-handling units.
 - 3) Provide one service light fixture in fan[, **coil**][**filter**]<Insert section> sections of air-handling units.
5. Toggle Switches for Service Light Fixtures:
 - a. Single-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
 - b. Two-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
 - c. Three-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
 - d. Four-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
 - e. Lighted Single-Pole Switches, 120/277 V, 20 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.
 - 1) Description: Handle illuminated when switch is on.
 - f. Toggle Switch Box and Cover: Mount toggle switch in a [**metal**][**cast-aluminum**] outlet box with [**cast-aluminum**][**or**][**stainless steel**] cover.
 - g. Application:
 - 1) Factory install service light switches at locations indicated on Drawings.
 - 2) Factory install a single service light switch to switch all service light fixtures from a single location.
 - 3) Factory install a service light switch for each service light fixture or group of service light fixtures accessible from a single access door adjacent to the access door.
 - 4) Factory install switching configuration (single, three way, or four way) required to operate a single service light fixture or group of service light fixtures from any access door that opens to respective service light fixtures.
 - h. Switches with Lighted Handles Applications: Lighted handle feature may be omitted where on/off status of internal lights can be viewed through an access door window.
6. Receptacles:
 - a. Isolated-Ground Duplex Receptacles, 125 V, 20 A:
 - 1) Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.
 - 2) Configuration: NEMA WD 6, Configuration 5-20R.
 - 3) Standards: Comply with UL 498 and FS W-C-596.
 - b. Duplex GFCI Receptacles, 125 V, 20 A:
 - 1) Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
 - 2) Configuration: NEMA WD 6, Configuration 5-20R.
 - 3) Type: Non-feed through.
 - 4) Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
 - c. Receptacle Box and Cover: Mount receptacle in a [**metal**][**cast-aluminum**] outlet box with [**cast-aluminum**][**or**][**stainless steel**] cover.
 - d. Applications: Factory install a receptacle in a convenient and field-accessible location on

air-handling unit exterior of casing [at locations indicated on Drawings][near access doors accessing fans][near access doors accessing electric heaters and fans][near access doors accessing energy wheels and fans][near access doors accessing electric heaters, energy wheels, and fans]<Insert locations>.

7. Power Supply to Fan Motors:

- a. As indicated on Drawings.
- b. Factory install a [disconnect switch][junction box][motor controller][variable-frequency controller] for each fan motor.
 - 1) Locate in a convenient and field-accessible location on unit exterior.
 - 2) Installation shall comply with NFPA 70.
 - 3) Wire, Conduit, and Enclosures:
 - a) Minimum Conduit Size: [3/4 inch (20 mm)]<Insert dimension>.
 - b) Materials: Metal, corrosion resistant[and constructed of stainless steel].
 - c) Motor Termination: Flexible conduit, NRTL listed, not to exceed 36 inches (900 mm) long.
 - d) Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware[constructed of stainless steel].
 - e) Wire: Copper, rated for 600 V, solid wire for size [No. 10 AWG]<Insert wire size> and smaller and stranded wire for larger sizes.
 - f) Minimum Wire Size: [No. 12 AWG]<Insert wire size>.
 - g) Each circuit shall have a ground wire.
 - h) Install wire in conduit.
 - i) Boxes, Conduit Outlet Boxes, and Enclosures Located in Airstream: NEMA 250, [Type 4][Type 4X][or][Type 12]<Insert Type>.
 - j) Boxes, Conduit Outlet Boxes, and Enclosures Located on Exterior of Air-Handling Unit Casing: NEMA 250, [Type 1][or][Type 12]<Insert Type>.

8. Disconnect Switches:

- a. Specification Grade: "Heavy duty type"; "quick-make," "quick-break" construction.
- b. Three pole, [fused][or][nonfused].
- c. 600 V rated.
- d. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than [42,000][65,000]<Insert value> A.
- e. Enclosure: NEMA 250, [Type 1][Type 12]<Insert Type>.
- f. Operating handle shall be of box-mounted type that directly drives switch mechanism.
- g. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
- h. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
- i. Include a solid neutral as required by authorities having jurisdiction.
- j. Disconnect switch shall have a ground lug for ground wire termination.
- k. Operating handle shall be lockable in open position.
- l. Horsepower rated.
- m. Feed through or double lugged.

9. Motor Field Power Junction Box:

- a. Provide junction box with internal wire terminal block mounted on unit exterior for interface

with field power wiring.

- 1) Provide for each motor not installed with a factory disconnect or controller with integral disconnect.

b. Factory install internal wiring and conduit to motor.

10. Motor Controllers:

- a. NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.
- b. Configured for control of single- or multispeed motors as indicated.
- c. Enclosure: NEMA 250, [Type 1][Type 12]<Insert Type>, with hinged full-front access door with lock and key.
- d. Externally Operated Disconnect: [Door-interlocked disconnect switch][Fused disconnect switch][Nonfused disconnect switch][Circuit breaker] with lockable handle.
- e. Short-Circuit Current Rating: As required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
- f. Hand-Off-Auto Switch: Mounted on face of enclosure.
- g. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
- h. Control Relays: Time-delay relays.
- i. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
- j. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
- k. Number-of-Starts Counter: Numerical readout on face of enclosure.

11. Variable-Frequency Controllers:

- a. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
- b. Enclosure: Unit mounted, NEMA 250, [Type 1][Type 12]<Insert Type>, with hinged full-front access door with lock and key.
- c. Externally Operated Disconnect: [Door-interlocked disconnect switch][Fused disconnect switch][Nonfused disconnect switch][Circuit breaker] with lockable handle.
- d. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
- e. Technology: Pulse-width-modulation (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
- f. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
- g. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
- h. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
- i. Operating Requirements:
 - 1) Input AC Voltage Tolerance: [10]<Insert number> percent.
 - 2) Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - 3) Capable of driving full motor load, without derating.
 - 4) Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 5) Minimum Displacement Primary-Side Power Factor: 95 percent.
 - 6) Overload Capability: 1.05 times the full-load current for 7 seconds.
 - 7) Starting Torque: As required by fan and motor drive assembly.
 - 8) Speed Regulation: 1 percent.
 - 9) Speed Range: 10:1 speed range.
 - 10) To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate

- continuously.
- 11) Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
- j. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
- k. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or need for replacement:
 - 1) Surge suppression.
 - 2) Loss of input signal protection.
 - 3) Critical frequency rejection.
 - 4) Overtemperature.
 - 5) Short circuit at controller output.
 - 6) Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
 - 7) Open circuit at controller output.
 - 8) Input undervoltage.
 - 9) Input overvoltage.
 - 10) Loss of input phase.
 - 11) Reverse phase.
 - 12) AC line switching transients.
 - 13) Instantaneous overload, line to line, or line to ground.
 - 14) Sustained overload exceeding 100 percent of controller rated current.
 - 15) Starting a rotating motor.
 - 16) **<Insert features>**.
- l. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
- m. Automatic Reset and Restart:
 - 1) Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
 - 2) Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
- n. Visual Indication: On face of controller; indicating the following conditions:
 - 1) Power on.
 - 2) Run.
 - 3) Overcurrent and overvoltage.
 - 4) Motor speed (percentage).
 - 5) Various faults with alarm status.
 - 6) Input kilovolt amperes.
 - 7) Power factor.
 - 8) Input kilowatts and kilowatt-hours.
 - 9) Three-phase input and output voltage.
 - 10) Three-phase input and output current.
 - 11) Output frequency.
 - 12) Elapsed operating time (hours).
 - 13) Diagnostic and service parameters.
 - 14) **<Insert conditions>**.
- o. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
- p. Hardwired Control Signal Interface: A minimum of [two]**<Insert number>** analog inputs (0

- to 10 V or 0/4 to 20 mA) and [four]<Insert number> programmable digital inputs.
- q. Remote Communication Interface: [ASHRAE 135 BACnet MS/TP][ASHRAE 135 BACnet IP]<Insert requirements>.
- r. Line Conditioning:
 - 1) Input line conditioning.
 - 2) Output filtering.
 - 3) EMI/RFI filtering.
- s. Bypass Controller:
 - 1) Bypass Controller/Variable-Frequency Controller Selector Switch: Include manual selector switch on face of enclosure for local operator control of preferred controller.
 - 2) Bypass Mode: [Manual operation only][Field-selectable automatic or manual].
 - a) In automatic mode, include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.
 - 3) Type: Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.
 - 4) Arrangement: Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller for safe servicing of variable-frequency controller.
 - 5) Enclosure: Install bypass controller in same enclosure as variable-frequency controller.
 - 6) Remote Monitoring: Include control relay for remote indication of bypass controller operation.

MM. Factory-Assembled Controls:

- 1. General:
 - a. Air-handling unit manufacturer shall furnish and factory install control instruments, control power circuit, control transformers, power supplies, wiring, tubing, raceways, and control panels.
 - b. Provide for a single-point field connection to [120][277]-V electrical power for all factory-installed controls. Terminate power connection with a toggle switch mounted in control panel.
 - c. Control panel shall serve as field tie-in point for all electric damper actuators, and control instruments located within air-handling unit. Controls for control dampers, control valves, and instruments installed in ductwork and piping are not included as part of air-handling unit factory-installed controls.
 - d. Control instruments shall be installed in accordance with manufacturer's written instructions.
 - e. Control panel shall house flow, moisture, pressure and temperature transmitters, transformers, dc voltage power supplies, and wiring terminal strip.
 - f. Carbon dioxide transmitters shall be mounted on air-handling unit casing exterior with sensor port exposed to the airstream.
 - g. Factory install the following control instruments:
 - 1) Flow station and flow transmitter for each fan.
 - 2) Pressure sensors (inlet and discharge) and one combination pressure differential transmitter, switch, and controller for each filter bank installed in the air-handling unit.
 - 3) Pressure sensor and combination pressure differential transmitter, switch, and

- controller at the inlet of each fan.
- 4) Pressure sensor and combination pressure differential transmitter, switch, and controller at the discharge of each fan.
- 5) Carbon dioxide sensor/transmitters at locations indicated on Drawings.
- 6) Moisture and temperature sensors and transmitters at locations indicated on Drawings.
- 7) Temperature switches at locations indicated on Drawings.
- 8) Control instruments indicated on Drawings.
- 9) **<Insert requirements>**.

2. Wire and Cable:

a. Single Conductor Control Wiring above 24 V:

- 1) Wire size shall be at least No. 16 AWG.
- 2) Conductor shall be 7/24 soft annealed copper stranding with a **2- to 2-1/2-inch (50- to 65-mm)** lay.
- 3) Conductor insulation shall be 600 V, Type THWN or Type THHN, 90 deg C in accordance with UL 83.
- 4) Conductor colors shall be black (hot), white (neutral), and green (ground).

b. Single Twisted Shielded Instrumentation Cable above 24 V:

- 1) Wire size shall be minimum No. 18 AWG.
- 2) Conductors shall be a twisted, 7/24 soft annealed copper stranding with a **2- to 2-1/2-inch (50- to 65-mm)** lay.
- 3) Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
- 4) Shielding shall be 100 percent 0.35/0.5-mil aluminum/mylar tape, helically applied with 25 percent overlap, and aluminum side in with a No. 18 AWG-7/26 tinned copper drain wire.
- 5) Outer jacket insulation shall have a 600-V, 90 deg C rating and shall be Type TC cable.
- 6) For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red, and white.

c. Single Twisted Shielded Instrumentation Cable 24 V and Lower:

- 1) Wire size shall be minimum No. 18 AWG.
- 2) Conductors shall be a twisted, 7/24 soft annealed copper stranding with a **2- to 2-1/2-inch- (50- to 65-mm)** lay.
- 3) Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
- 4) Shielding shall be 100 percent 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with a No. 20-22 AWG tinned copper drain wire.
- 5) Outer jacket insulation shall have a 300-V, 105 deg C rating and shall be Type PLTC cable.
- 6) For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red, and white.

d. Wire and Cable Installation:

- 1) Comply with manufacturer's written instructions and NFPA 70.
- 2) Grounding shall be in accordance with IEEE C2. Ground wire shall be copper. Demonstrate ground resistance.

- 3) Wiring and cables shall be installed in conduit. Exposed wire and cable are unacceptable.
- 4) Wire and cables may be grouped in a common raceway, except do not group wires and cables from different voltages.
- 5) Install control wiring in a separate conduit from power wiring.
- 6) Wiring shall be continuous from terminal to terminal without splices.
- 7) Do not install low-voltage wire and cable closer than **[12 inches (300 mm)]<Insert distance>** from line voltage electrical power wire and cables. Provide an installation free of EMI.
- 8) Use insulated spade lugs for wiring connection to screw terminals.
- 9) Use shielded cable to transmitters.
- 10) Terminate wiring and cables within a control panel, within instrument housing, or in a junction box. Clamp the cable over the jacket, in the junction box. Individual conductors in the stripped section of cable shall be slack between clamping point and terminal block.
- 11) Terminate wire and cable in control panel with terminal blocks.
- 12) Identify each wire and cable on each end and at each terminal with a number-coded identification tag. Each wire and cable conductor shall have a unique tag.
- 13) Perform continuity and meager testing on wiring and cable.

3. Raceways:

a. Conduit:

- 1) Install wiring and cable in conduit.
- 2) Minimum Conduit Size: **[1/2 inch (13 mm)][3/4 inch (20 mm)]<Insert dimension>**.
- 3) Materials: Metal, corrosion resistant **[and constructed of stainless steel]**.
- 4) Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware **[constructed of stainless steel]**.
- 5) Terminations to Actuators and Instruments: Flexible conduit, NRTL listed, not to exceed **24 inches (600 mm)** long.

b. Boxes, Conduit Outlet Boxes, and Enclosures:

- 1) Located in Airstream: NEMA 250, **[Type 4][Type 4X][or][Type 12]<Insert Type>**.
- 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 1][or][Type 12]<Insert Type>**.

c. Seals: Seal pathways to prevent air leakage between air-handling unit exterior and interior, and between internal component sections.

d. Conduit Installation:

- 1) Conduit shall be continuous and secured in a manner that is electrically continuous throughout.
- 2) Secure threaded conduit entering a cabinet, box, or enclosure with a locknut on outside and on inside, such that conduit system is electrically continuous throughout.
 - a) Install a metal bushing with insulated throat on inside.
 - b) Locknuts designed to bite into metal, or on inside of enclosure and shall have a grounding wedge lug under locknut.
- 3) Conduit box connectors for conduit entering enclosures shall be insulated throat type.
- 4) Connect conduit with watertight sealing locknuts that are suitable for wet applications.
- 5) Offset conduits where they enter surface-mounted equipment and panels.

- 6) Neatly loop and lace wiring installed in panels and other enclosures.
 - 7) Seal conduit runs to prevent the circulation of air by installing seal fittings.
 - 8) Install conduit inside of air-handling unit casing. Wiring and conduit running on exterior of air-handling unit casing is unacceptable.
4. Tubing and Fittings:
- a. Products in this subparagraph are intended for use with the following:
 - 1) Main air and signal air to pneumatically controlled instruments, actuators, and other control devices and accessories.
 - 2) Signal air between pressure instruments, such as sensors, switches, transmitters, controllers, and accessories.
 - b. Copper Tubing:
 - 1) Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties in accordance with ASTM B75/B75M.
 - 2) Performance, dimensions, weight, and tolerance in accordance with ASTM B280.
 - 3) Diameter, as required by application, not less than nominal **0.25 inch (6 mm)**.
 - 4) Wall thickness, as required by application, but not less than **0.030 inch (0.8 mm)**.
 - c. Copper Tubing Fittings: Brass, compression type.
 - d. Polyethylene Tubing:
 - 1) Fire-resistant black virgin polyethylene in accordance with ASTM D1248, Type 1, Class C, and Grade 5.
 - 2) Tubing shall comply with stress crack test in accordance with ASTM D1693.
 - 3) Diameter, as required by application, of not less than nominal **0.25 inch (6 mm)**.
 - e. Polyethylene Tubing Fittings: Brass, compression type.
 - f. Stainless Steel Tubing:
 - 1) Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale.
 - 2) Chemical and physical properties in accordance with ASTM A269/A269M.
 - 3) Diameter, as required by application, of not less than nominal **0.25 inch (6 mm)**.
 - 4) Wall thickness, as required by application, but not less than **0.035 inch (0.9 mm)**.
 - 5) Furnish stainless steel tubing in **[20-foot (6-mm)]** straight random lengths.
 - g. Stainless Steel Tubing Connectors and Fittings:
 - 1) Connectors and fittings shall be stainless steel, with stainless steel collets, flareless type.
 - 2) Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.
 - h. Tubing Installation:
 - 1) Use **[copper][or][stainless steel]** tubing except use fire-resistant polyethylene for tubing located in control panels.
 - 2) Run tubing parallel to, and at right angles to, casing.
 - 3) Route multiple runs of tubing in neat parallel lines.
 - 4) Support tubing as follows:

- a) Support metal tubing with hangers, clips, and tube trays.
 - b) Do not use tapes for mounting tubing.
 - c) Place a support within **1 foot (0.3 m)** of each change in direction and each branch take-off.
 - d) Spacing between supports shall not exceed **[60 inches (1500 mm)]<Insert distance>**.
- 5) Tubing shall not interfere with access to dampers and equipment or obstruct passageways of any kind.
 - 6) Provide vibration loops in tubing when connecting to equipment that might vibrate.
 - 7) Where joining or mating dissimilar metals where galvanic action could occur, provide dielectric isolation.
 - 8) Make tubing bends with a bending tool. Hard bends, or wrinkled or flattened bends are unacceptable.
 - 9) Install tubing fitting makeup in accordance with manufacturer's written instructions.
 - 10) Do not make tubing connections to a fitting before completing makeup connection.
 - 11) Properly align tubing with fitting. Springing tube into position can result in excessive stress on both tubing and fitting with possible resulting leaks.
 - 12) Do not install fittings close to a bend. Length of straight tubing, not deformed by bending, is required for a proper connection.
 - 13) Check tubing for correct diameter and wall thickness. Tube ends shall be cut square and deburred. Exercise care during cutting to keep tubing round.
 - 14) Wrap threads of fittings with a single wrap of PTFE tape.
 - 15) Install tubing with extreme care to keep foreign matter out. Keep open ends of tubing plugged to keep out dust, dirt, and moisture.
 - 16) Mark each tube on each end with a number-coded identification. Each tube shall have a unique number.
 - 17) Test tubing as follows:
 - a) Test for leaks and obstructions. Disconnect each tubing run before test is run, and blow out trash, condensate, and other foreign material with compressed air.
 - b) After foreign matter is expelled and the line is free from obstructions, plug the far end of tubing run.
 - c) Connect a pressure source to the near end with a needle valve between air supply and tubing run. Only commercially pure dry compressed air or nitrogen as distributed in gas cylinders is acceptable for this test.

5. Control Panels:

- a. Design control panels for grouping and protecting various electric, and/or electronic components.
- b. NRTL listed in accordance with UL 50 or UL 50E.
- c. NEMA 250, **[Type 1][or][Type 12]<Insert Type>** enclosure.
- d. Construct enclosure of steel, not less than the following:
 - 1) Enclosure Size Less Than 24 Inches (600 mm): **[0.053 inch (1.35 mm)][or][0.067 inch (1.7 mm)]** thick.
 - 2) Enclosure Size 24 Inches (600 mm) and Larger: **[0.067 inch (1.7 mm)][or][0.093 inch (2.36 mm)]** thick.
- e. Support front panel using a non-removable piano hinge that runs entire height of cabinet.
- f. Each panel shall not exceed height of air-handling unit casing and **72 inches (1800 mm)** high.
- g. Secure front panel with a key locking mechanism. Common key the locks, and provide one pair of keys per panel.

- h. Front panel with a window of size so all instrument displays are visible with door closed.
 - i. Mount panels on exterior wall of air-handling unit casing on primary access side of unit.
 - j. Paint control panel exterior with enamel at least 5 mils thick. Color of panel exterior and interior shall be white.
 - k. Include panel field power supply with a toggle-type switch located at entrance inside panel to disconnect power.
 - l. Include panel with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
 - m. Size control panel to provide at least 25 percent spare area on subpanel.
 - n. Arrange control panel so similar type equipment is grouped together, and a barrier is installed between electrical and electronic equipment.
 - o. Interior ambient temperature shall not rise above manufacturer's recommended maximum operating temperature for products installed within the panels. Provide filtered louvers and circulating fans, when necessary, to meet this criteria.
 - p. Panel shall serve as a central tie-in point for control devices such as remote sensors, transmitters, power supplies, and transformers.
 - 1) Factory install internal wiring in compliance with specified standards.
 - 2) Terminate wiring using an electric terminal strip with heavy-duty terminal blocks.
 - 3) Include spare terminals, equal to not less than **[10][20]<Insert number>** percent of used terminals.
 - 4) Include spade lugs for stranded wire.
 - 5) Install a maximum of two wires on each side of a terminal.
 - 6) Label each end of cable, wire, and tubing within panel following an approved identification system.
 - q. Polyethylene tubing may be used within panel enclosure in place of copper.
 - r. Supply each control panel with a complete set of as-built schematics, tubing, and wiring diagrams that are bound in a three-ring protective binder and located within panel.
 - s. Mount instruments and other products within control panel on an internal panel(s) and provide with nameplates. Provide engraved, laminated phenolic nameplates (black letters on a white background). Nameplates shall have at least **1/4-inch- (6-mm-)** high lettering.
 - t. Route tubing, cable, and wiring located inside control panel within a raceway that has a continuous removable cover.
6. Pitot Tube Airflow Stations:
- a. Fan Inlet Airflow Sensor (Piezometer Ring):
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a) **[ebm-papst Inc.]**
 - b) **[Greenheck Fan Corporation]**
 - c) **[Twin City Fan & Blower]**
 - d) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[ebm-papst Inc.]**

- b) [Greenheck Fan Corporation]
- c) [Twin City Fan & Blower]
- d) <Insert manufacturer's name>

- 3) Source Limitations: Obtain sensors from single source from single manufacturer.
- 4) Provide fans with airflow measurement integral to fan inlet cones for continuously measurement of air volume flow rate.
- 5) Fan inlet airflow sensor shall contain multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.
- 6) Sensor points shall neither protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.
- 7) Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.
- 8) Sensor shall be non-intrusive and not impact fan performance.
- 9) Product shall be a standard offering of fan manufacturer and include published literature with supporting test data to validate sensor performance.

7. Thermal Airflow Measurement Stations:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) [Air Monitor; an ONICON Brand]
 - 2) [Ebtron, Inc]
 - 3) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Air Monitor; an ONICON Brand]
 - 2) [Ebtron, Inc]
 - 3) <Insert manufacturer's name>
- c. Source Limitations: Obtain stations from single source from single manufacturer.
- d. Description: Airflow station shall consist of one or more sensor probes and a remotely mounted microprocessor-based transmitter.
- e. Performance:
 - 1) Capable of independently processing up to [16]<Insert number> independently wired sensor assemblies.
 - 2) Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
 - 3) Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output unless temperature sensor has an accuracy of 0.1 deg F (0.06 deg C).
 - 4) Listed and labeled by an NRTL as successfully tested as an assembly in accordance with UL 873 or UL 60730.
 - 5) Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-plenum-rated cable placed in conduit.
 - 6) Each flow station shall be factory calibrated at a minimum of [six][16]<Insert number> airflow rates and [two][three]<Insert number> temperatures to standards that are traceable to NIST.

- 7) Individual Sensor Airflow Accuracy: Within [2][3]<Insert number> percent of reading over the entire operating airflow range.
 - 8) Thermal Airflow Station Assembly Airflow Accuracy: Within [2][3][5]<Insert number> percent of reading over the entire operating airflow range.
 - a) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets performance requirements throughout the measurement range.
 - 9) Temperature Accuracy: Within **0.2 deg F (0.11 deg C)** over entire operating range of **minus 20 to plus 140 deg F (minus 29 to plus 60 deg C)**.
 - 10) Sensor Ambient Operating Temperature Range: **Minus 20 to plus 160 deg F (Minus 29 to plus 71 deg C)**.
 - 11) Transmitter Ambient Operating Temperature Range: **Minus 20 to plus 120 deg F (Minus 29 to plus 49 deg C)**.
 - 12) Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, noncondensing.
 - 13) Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
 - 14) Pressure Drop: **0.05 inch wg (12.5 Pa)** at **2000 fpm (10.2 m/s)** across a **24-by-24-inch (600-by-600-mm)** area.
 - 15) Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than [1][2]<Insert number> percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan to deliver Project design airflow indicated.
- f. Sensor Assemblies:
- 1) Each sensor probe shall contain two individually wired, hermetically sealed **[bead-in-glass]**thermistors.
 - 2) Mount thermistors in sensor using a marine-grade, waterproof material.
 - 3) Thermistor leads shall be protected and not exposed to environment.
 - 4) Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.
 - 5) Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
 - 6) Sensor Probe Material: Gold anodized, extruded Alloy 6063 aluminum tube or Type 304 stainless steel.
 - 7) Probe Assembly Mounting Brackets Material: Type 304 stainless steel.
- g. Transmitter:
- 1) Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
 - 2) Capable of field configuration and diagnostics using an onboard push-button interface and digital display.
 - a) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:
 - b) Power switch to include integral protection from transients and power surges.
 - c) Power switch circuitry to ensure reset after power disruption, transients, and brownouts.

- d) Power switch to include integral transformer to convert field power source to operating voltage required by instrument.
- 3) Remote Signal Interface:
 - a) Linear Analog Signals for Airflow[**and Temperature**]: Fuse protected and isolated, **[field selectable,][0 to 10 V dc][or][4 to 20 mA]**.
 - b) RS-485: BACnet-ARCNET, BACnet-MS/TP, and Modbus-RTU.
 - c) 10 Base-T Ethernet: BACnet Ethernet, BACnet-IP, Modbus-TCP, and TCP/IP.
 - d) LonWorks free topology.
- 8. Flow Transmitters for Pitot Tube Sensors:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sensors from single source from single manufacturer.
 - d. Receives total and static pressure signals from a flow element, amplify, extract the square root, and scale the signal to produce a 4- to 20-mA dc output signal linear to airflow.
 - e. Housed in NEMA 250, Type 1 enclosure.
 - f. Assembly constructed so that shock, vibration, and pressures surges of up to **1 psig (6.9 kPa)** will neither harm transmitter nor affect its accuracy.
 - g. Provide transmitter with an automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. Automatic zeroing circuit shall re-zero transmitter to within 0.1 percent of true zero.
 - h. Performance:
 - 1) Range: At least 20 percent below minimum airflow and 20 percent greater than design airflow.
 - 2) Calibrated Span: Field adjustable, minus 40 percent of the range.
 - 3) Accuracy: Within 0.10 percent of natural span.
 - 4) Repeatability: Within 0.15 percent of calibrated span.
 - 5) Linearity: Within 0.2 percent of calibrated span.
 - 6) Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
 - i. Equip transmitter with an integral digital LED or LCD for continuous indication of airflow.
 - j. Install in control panel.
- 9. Humidity Sensors and Transmitters with Digital Display:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- 1) [Vaisala]
 - 2) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Vaisala]
 - 2) <Insert manufacturer's name>
 - c. Source Limitations: Obtain sensors and transmitters from single source from single manufacturer.
 - d. Performance:
 - 1) Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 2.5 percent from 90 to 100 percent relative humidity when operating between **60 to 77 deg F (16 to 25 deg C)**.
 - 2) Relative Humidity Range: Zero to 100 percent.
 - 3) Factory calibrated and NIST traceable with certificate included.
 - e. Construction:
 - 1) Provide housing with remote sensor probe for ducted applications.
 - a) Duct Sensor Body: 300 series stainless steel or chrome-plated aluminum, at least **2 inches (50 mm)** long for duct-mounted applications.
 - b) Provide sensor with cable for field installation in conduit.
 - c) For duct-mounted applications, thread the sensor assembly for connection to a threaded mounting flange.
 - 2) Provide general-purpose humidity sensor unless application requires special requirements. Provide sensor with sintered stainless steel filter.
 - 3) Housing shall be ABS/PC plastic or powder-coated aluminum.
 - 4) Housing Classification: NEMA 250, Type 4 or Type 4X.
 - 5) Provide housing with wall-mounting plate.
 - f. Output Signal: Two-wire, 4- to 20-mA output signal with a drive capacity of at least 500 ohms at 24 V dc.
 - g. Provide unit with a digital display of relative humidity in percent.
10. Air Pressure Sensors:
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Dwyer Instruments, Inc]
 - 2) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Dwyer Instruments, Inc]

- 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sensors from single source from single manufacturer.
 - d. Insertion length shall be **[4 inches (100 mm)][6 inches (150 mm)][8 inches (200 mm)][12 inches (300 mm)]**.
 - e. Sensor with four radial holes of **0.04-inch (1-mm)** diameter.
 - f. **[Brass][or][stainless steel]** construction.
 - g. Sensor with threaded end support, sealing washers, and nuts.
 - h. Connection: **NPS 1/4 (DN 6)** compression fitting.
11. Air-Pressure Differential Indicating Transmitter, Switch, and Controller:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Dwyer Instruments, Inc]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Dwyer Instruments, Inc]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain from single source from single manufacturer.
 - d. Description:
 - 1) Three-in-one instrument, including digital display, control relay switches, and a transmitter with a current output.
 - 2) Field configurable for pressure, velocity, and volumetric flow applications through user interface.
 - 3) Select instrument range based on application. Range shall be approximately 2 times set point.
 - e. Performance:
 - 1) Accuracy Including Hysteresis and Repeatability:
 - a) Within 1 percent for ranges less than **5 inches wg (1250 Pa)**.
 - b) Within 0.5 percent at **77 deg F (25 deg C)** for other ranges.
 - 2) Stability: Within 1 percent per year.
 - 3) Response Time: 250 ms.
 - 4) Overpressure: **5 psig (34 kPa)** for instrument ranges less than **50 inches wg (12.5 kPa)** and **9 psig (62 kPa)** for **100-inch wg (25-kPa)** range.
 - 5) Temperature Limits: **32 to 140 deg F (0 to 60 deg C)**.
 - 6) Thermal Effects: 0.020 percent per deg F.
 - 7) Warm-up Period: One hour.
 - f. Controller Programming through Menu Keys to Access Five Menus:
 - 1) Security level.
 - 2) Pressure, velocity, or flow application.

- 3) Engineering units.
 - 4) K-factor for use with flow application.
 - 5) Set-point control only; set-point and alarm operation; and alarm operation as high, low, or high/low with manual or automatic reset and delay.
 - 6) View high and low readings.
 - 7) Digital dampening for smoothing erratic applications.
 - 8) Scaling of analog output to fit range and field calibration.
- g. Display:
- 1) Digital, four-digit display with backlight, with **0.4-inch- (10-mm-)** high, alphanumeric characters.
 - 2) Four indicators; two for set point and two for alarm status.
- h. Operator Interface:
- 1) Set-point adjustment through keypad on face of instrument.
 - 2) Zero and span adjustments accessible through menu.
 - 3) Programming through keypad.
- i. Analog Output Signal:
- 1) Two-wire, 4- to 20-mA dc current source.
 - 2) Signal capable of operating into a 900-ohm load.
- j. Digital Output Signal:
- 1) Two SPDT relays.
 - 2) Each rated for 1 A at 30 V ac or dc.
- k. Construction:
- 1) Die cast-aluminum casing and bezel.
 - 2) Threaded, **NPS 1/8 (DN 6)** connections on side and back.
 - 3) Vertical plane mounting.
 - 4) NEMA 250, Type 1.
 - 5) Nominal **4-inch- (100-mm-)** diameter face.
 - 6) Mounting Bracket: Appropriate for installation.
12. Carbon Dioxide Sensors/Transmitters:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
- 1) **[Vaisala]**
 - 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[Vaisala]**
 - 2) **<Insert manufacturer's name>**

- c. Source Limitations: Obtain sensors/transmitters from single source from single manufacturer.
 - d. Description:
 - 1) NDIR technology or equivalent technology providing long-term stability and reliability.
 - 2) Two-wire, 4- to 20-mA output signal; linearized to carbon dioxide concentration in ppm.
 - e. Construction:
 - 1) House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 4.
 - 2) Equip with digital display for continuous indication of carbon dioxide concentration.
 - f. Performance:
 - 1) Measurement Range: 0 to 2000 ppm.
 - 2) Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
 - 3) Repeatability: Within 1 percent of full scale.
 - 4) Temperature Dependence: Within 0.05 percent of full scale over an operating range of **25 to 110 deg F (minus 4 to plus 43 deg C)**.
 - 5) Long-Term Stability: Within 5 percent of full scale after more than five years.
 - 6) Response Time: Within 60 seconds.
 - 7) Warm-up Time: Within five minutes.
 - g. Provide calibration kit. Turn over to Owner at start of warranty period.
13. Air Temperature Sensors:
- a. Platinum Resistance Temperature Detector (RTD): Common Requirements:
 - 1) 100 or 1000 ohms at 0 deg C and a temperature coefficient of 0.00385 ohms/ohm/deg C.
 - 2) Two-wire PTFE-insulated **22-gauge (0.65-mm)** stranded copper leads.
 - 3) Performance Characteristics:
 - a) Range: **Minus 50 to plus 275 deg F (Minus 46 to plus 135 deg C)**.
 - b) Interchangeable Accuracy: At **32 deg F (0 deg C)** within **0.5 deg F (0.3 deg C)**.
 - c) Repeatability: Within **0.5 deg F (0.3 deg C)**.
 - d) Self-Heating: Negligible.
 - 4) Transmitter Requirements:
 - a) Transmitter required for each 100-ohm RTD.
 - b) Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.
 - b. Platinum RTD, Averaging Sensor:
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**



- a) **[Minco]**
 - b) **<Insert manufacturer's name>**
- 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a) **[Minco]**
 - b) **<Insert manufacturer's name>**
- 3) Source Limitations: Obtain sensors from single source from single manufacturer.
 - 4) **[100][or][1000]** ohms.
 - 5) Temperature Range: **Minus 50 to plus 275 deg F (Minus 45 to plus 135 deg C).**
 - 6) Multiple sensors to provide average temperature across entire length of sensor.
 - 7) Rigid probe of aluminum, brass, copper, or stainless steel sheath.
 - 8) Flexible probe of aluminum, brass, copper, or stainless steel sheath and formable to a **4-inch (100-mm)** radius.
 - 9) Length: As required by application to cover entire cross section of air tunnel.
 - 10) Enclosure: Junction box with removable cover; NEMA 250, Type 4.
 - 11) Gasket for attachment to duct or equipment to seal penetration airtight.
 - 12) Conduit Connection: **1/2-inch (13-mm)** trade size.
14. Air Temperature Switches:
- a. Thermostat and Switch for Low Temperature Control:
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a) **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - b) **[Siemens Industry, Inc., Building Technologies Division]**
 - c) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - b) **[Siemens Industry, Inc., Building Technologies Division]**
 - c) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain switches from single source from single manufacturer.
 - 4) General:
 - a) Two-position control.
 - b) Field-adjustable set point.
 - c) Manual reset.
 - d) NRTL listed.
 - 5) Performance:
 - a) Operating Temperature Range: **15 to 55 deg F (Minus 9 to plus 13 deg C).**
 - b) Temperature Differential: **5 deg F (2.8 deg C),** non-adjustable and additive.

- c) Enclosure Ambient Temperature: **Minus 20 to plus 140 deg F (Minus 11 to plus 60 deg C).**
 - d) Sensing Element Maximum Temperature: **250 deg F (121 deg C).**
 - e) Voltage: 120 V ac.
 - f) Current: 16 full-load A.
 - g) Switch Type: Two SPDT snap switches operate on coldest **12-inch (300-mm)** section along element length.
 - 6) Construction:
 - a) Vapor-Filled Sensing Element: Nominal **20 feet (6 m)** long.
 - b) Dual Temperature Scale: Fahrenheit and Celsius visible on face.
 - c) Set-Point Adjustment: Screw.
 - d) Enclosure: Painted metal, NEMA 250, Type 1.
 - e) Electrical Connections: Screw terminals.
 - f) Conduit Connection: **1/2-inch (13-mm)** trade size.
15. Air Temperature RTD Transmitters:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain transmitters from single source from single manufacturer.
 - d. House electronics in NEMA 250 Type 1 enclosure. Mount transmitter in control panel.
 - e. Conduit Connection: **1/2-inch (13-mm)** trade size.
 - f. Functional Characteristics:
 - 1) Input:
 - a) 100-ohm platinum RTD temperature coefficient of 0.00385 ohms/ohms/deg C; two-wire sensors.
 - b) 1000-ohm platinum RTD temperature coefficient of 0.00385 ohms/ohms/deg C; two-wire sensors.
 - 2) Span (Adjustable):
 - a) Exhaust Air: **50 to 100 deg F (10 to 38 deg C).**
 - b) Mixed Air: **Minus 40 to plus 140 deg F (Minus 40 to plus 60 deg C).**
 - c) Outdoor: **Minus 40 to plus 140 deg F (Minus 40 to plus 60 deg C).**
 - d) Supply Air, Cooling, and Heating: **40 to 120 deg F (4 to 49 deg C).**
 - e) Return Air: **50 to 100 deg F (10 to 38 deg C).**
 - 3) Output: 4- to 20-mA dc linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24 V dc.

- 4) Zero and span field adjustments plus or minus 5 percent of span. Minimum span **50 deg F (28 deg C)**.
 - 5) Match sensor with temperature transmitter and factory calibrate together.
 - g. Performance Characteristics:
 - 1) Calibration Accuracy: Within 0.1 percent of span.
 - 2) Stability: Within 0.2 percent of span for at least 6 months.
 - 3) Combined Accuracy: Within 0.5 percent.
 - h. Provide each transmitter with a digital display.
16. Control Transformers:
- a. Size each transformer for the total connected load, plus an additional 25 percent of the connected load.
 - b. Each transformer shall be at least 100 VA.
 - c. Provide transformer with both primary and secondary fuses.
17. 25-V dc Power Supply:
- a. Plug-in style suitable for mating with a standard eight-pin octal socket.
 - b. Enclose circuitry within a housing.
 - c. Include line and load regulation to ensure a stable output. To protect both power supply and load, include power supply with an automatic current limiting circuit.
 - d. Performance:
 - 1) Output voltage nominally 25 V dc within 5 percent.
 - 2) Output current up to 100 mA.
 - 3) Input voltage nominally 120 V ac, 60 Hz.
 - 4) Load regulation within 0.5 percent from 0- to 100-mA load.
 - 5) Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
 - 6) Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.
18. Instrument Identification:
- a. Engraved tag bearing instrument identification.
 - 1) Each tag identifying an instrument shall have a unique identification that does not match identification of a similar device.
 - 2) Tag field instruments identified by equipment being controlled or monitored, followed by point identification used on I/O schematics.
 - 3) Example: DDC-AHU-01.01; PDIT1.
 - b. Letter size shall be minimum **1/4 inch (6 mm)** high.
 - c. Letter type shall be sans serif gothic bold style.
 - d. Lettering and background color scheme shall be white letters on black background.
 - e. Tag shall be engraved phenolic constructed of three layers of pressure rigid laminate. Top and bottom layers are color-coded, contrasting white center is exposed by engraving through outer layer. Engrave both sides. Material shall be stain proof, heat resistant, non-conductive, or non-corrosive.
 - f. Tag shall be fastened to equipment/instrument with drive pins or attached with a stainless steel chain.
 - g. Instruments furnished with identification tags provided by original manufacturer do not require an additional tag.

19. Checkout Procedures:

- a. Check instruments for proper location and accessibility.
- b. Check instruments for proper installation for direction of flow, elevation, orientation, and other applicable considerations.
- c. Damper Check-out: Verify that proper blade alignment, either parallel or opposed, has been provided.

20. Calibration and Adjustment:

- a. Calibrate every instrument.
- b. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
- c. Equipment and procedures used for calibration shall meet requirements of instrument manufacturer's written instructions. Test equipment used in calibration of instruments shall have an accuracy at least double that of instrument being calibrated.
- d. Calibrate each instrument in accordance with the accuracy outlined in instruction manual supplied for instrument by manufacturer.
- e. Control System Inputs and Outputs:
 - 1) Check analog inputs using a precision voltage or current source at zero, 50, and 100 percent of span.
 - 2) Check analog outputs using a milliamper meter at zero, 50, and 100 percent output.
 - 3) Check digital inputs using a jumper wire.
 - 4) Check digital outputs using an ohmmeter to test for contact making or breaking.
 - 5) Check resistance temperature inputs at zero, 50, and 100 percent of span using a precision-resistant source.
- f. Flow: Set differential pressure flow transmitters for zero and 100 percent values with three-point calibration accomplished at 100, 50, and 90 percent of span.
- g. Gas: Calibrate gas transmitters at zero, 50, and 100 percent of span.
- h. Humidity: Calibrate relative humidity transmitters at zero, 50, and 100 percent of span.
- i. Pressure: Calibrate pressure transmitters at zero, 50, and 100 percent of span.
- j. Temperature: Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.
- k. Dampers: Stroke and adjust control dampers following the recommended procedure from manufacturer, such that damper is 100 percent open and closed.
- l. Replace out-of-tolerance instruments failing the test.
- m. Provide diagnostic and test instruments for calibration and adjustment.

NN. Smoke Detectors:

1. System, Duct Smoke Detectors: For connection to conventional fire-alarm system. Coordinate requirements with **[Section 284600 "Fire Detection and Alarm"]****[and]****[Section 284614 "Single- and Multiple-Station Alarms."]**
 - a. Operating at 24 V dc, nominal.
 - b. Detectors shall be **[four]****[two]**-wire type.
 - c. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
 - d. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - e. Integral Visual-Indicating Light: LED type, indicating detector has operated **[and power-on status]**.

- f. Provide multiple levels of detection sensitivity for each sensor[, **with alarm-verification feature**].
- g. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
 - 1) Remote indication[**and test**] station.[**Operating key switch initiates an alarm test.**]
 - 2) Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC systems.
 - 3) Sampling Tubes: Design and dimensions as recommended by manufacturer for specific size, air velocity, and installation conditions where applied.
 - 4) Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.
- 2. Nonsystem, Single-Station Duct Smoke Detectors:
 - a. Nonsystem smoke detectors shall be listed as compatible with fire-alarm equipment installed or shall have a contact closure interface listed for the connected load.
 - b. Nonsystem smoke detectors shall comply with the monitoring for integrity requirements in NFPA 72.
 - c. Comply with UL 268A; operating at 120 V ac.
 - d. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to mounting brackets air-handling unit. Provide terminals in the fixed base for connection to building wiring.
 - 1) Enclosure: NEMA 250, Type 4X; listed for use with the supplied detector.
 - e. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific size, air velocity, and installation conditions where applied.
 - f. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.
- 3. Air-Handling Unit Factory Assembly:
 - a. Furnish and install smoke detectors inside air-handling units to comply with governing building codes.
 - b. Install smoke detectors in accordance with smoke detector manufacturer's written installation instructions.
 - 1) Sampling tubes shall extend the full width of airstream.
 - 2) Sampling tubes greater than **36 inches (900 mm)** long shall be supported on both ends.
 - c. Install smoke detectors within air-handling units in a location that is easily accessible for inspection, repair, and replacement of smoke detector, and in a location that does not hinder access to other internal components.
- 4. Air-Handling Unit Factory Testing: Functionally test smoke detectors to ensure proper operation in accordance with smoke detector manufacturer's written instructions.
- 5. Air-Handling Unit Factory Installation of Addressable Smoke Detectors Furnished by Building Fire-Alarm System Supplier:
 - a. Where addressable duct smoke detectors are indicated to be installed within air-handling unit casing, air-handling unit manufacturer shall install duct smoke detector components supplied by building fire-alarm system supplier.
 - b. Mount duct smoke detector sampling housing on exterior of air-handling unit casing. Locate on accessible side and coordinate with installers before installation.

- c. Seal air-handling unit casing penetrations.
- d. Install duct smoke detector components in accordance with written instructions furnished by supplier.
 - 1) Sampling tubes shall extend the full width of airstream.
 - 2) Sampling tubes greater than **36 inches (900 mm)** long shall be supported on both ends.
- e. Photograph installation and transmit photos to fire-alarm system Installer before air-handling unit shipment to ensure proper installation. Fire-alarm system Installer shall review photos and provide written acceptance of installation to air-handling unit manufacturer before air-handling unit shipment.
 - 1) Document date of photos and approval for record purposes.
 - 2) Make corrective measures required by fire-alarm system Installer as required for acceptance.
- f. Coordinate work schedule of air-handling unit manufacturer and fire-alarm system supplier to meet requirements of Project schedule.
- g. See **[Section 284600 "Fire Detection and Alarm"]****[and]****[Section 284614 "Single- and Multiple-Station Alarms"]****<Insert Section>** for additional requirements.

OO. Catwalks, Handrails, and Ladders:

- 1. General:
 - a. Provide elevated air-handling units and top levels of multilevel stacked units with catwalks, handrails, and ladders to provide service access.
 - b. Factory-fabricate catwalks, handrails, and ladders to ensure proper alignment and attachment.
 - c. Catwalks, handrails, and ladders may be disassembled and shipped separate from the air-handling unit for field installation.
 - d. Design and fabricate catwalk to be completely self-supported from air-handling unit frame without need for any type of field-installed supports.
 - e. Comply with OSHA requirements where requirements are more stringent than requirements indicated.
 - f. Install catwalk, handrails, and ladders level and plumb.
- 2. Catwalks:
 - a. Extend catwalks to service elevated portions of air-handling unit.
 - b. Catwalk width shall be of sufficient size to properly access and service equipment and maintain code-required clearances to electrical devices. Width shall be at least **[60 inches (1500 mm)]****<Insert dimension>** clear between the exterior casing and handrail.
 - c. Cantilever catwalk base frame from the air-handling unit base frame. Removable catwalks shall be bolted to the air-handling unit base frame at multiple points to ensure a rigid and firm attachment.
 - d. Catwalk base frame material and finish shall match air-handling unit frame.
 - e. Catwalk floor material shall match air-handling unit floor material.
 - f. Catwalk walking surface elevation shall match floor surface inside air-handling unit.
- 3. Handrails:
 - a. Provide catwalk with handrail, kneerail, toeboard, and vertical supports along entire length of catwalk. Comply with 29 CFR 1910.23.
 - b. Handrail shall be a minimum of **[42 inches (1050 mm)]****<Insert dimension>** high and

- comply with OSHA requirements. Vertical supports shall be spaced not more than [96 inches (2400 mm)]<Insert dimension> o.c.
- c. Construct handrail, kneerail, and vertical supports from not less than nominal [1-1/2-inch- (38-mm-)]<Insert dimension> diameter tube.
 - d. Handrail shall be capable of withstanding a live load force of not less than [100 lb./ft. (450 N/300 mm)] and a [200-lb (900-N)]<Insert value> concentrated force in any direction.
 - e. Provide lift-out sections of handrail to facilitate removal of air-handling unit internal components from the top-level to grade.
 - f. Provide self-closing gate at ends of catwalk accessible by ladders to provide fall protection.
 - g. Construct handrails, kneerails, toeboards, and vertical supports of [aluminum][fiberglass][galvanized-steel][or][stainless steel] materials.
- 1) Finish: Hot-dip galvanize assemblies constructed of steel after fabrication.
4. Ladders with Safety Cages:
- a. Provide a permanently attached ladder at [one][each] end of catwalk.
 - b. Ladder shall rise from building structural floor to the top of handrail.
 - c. Provide for construction tolerance and adjustable means to fasten the ladder at its base to the building structural floor.
 - d. Fabricate ladders with dimensions, spacing, details, and anchorages as required.
 - e. Comply with requirements of ALI A14.3 and 29 CFR 1910.27.
 - f. Support each ladder at top and bottom. Use welded or bolted brackets, designed for adequate support and anchorage, and to hold ladder [7 inches (175 mm)]<Insert dimension> clear from catwalk walking surface.
 - g. Extend rails at least [42 inches (1050 mm)]<Insert dimension> above top rung, and return rails with secure handholds fastened to handrail.
 - h. Construct ladders of [aluminum][fiberglass][galvanized-steel][or][stainless steel] materials.
- 1) Finish: Hot-dip galvanize ladders, brackets, and fasteners constructed of steel after fabrication.
- i. Provide non-slip surface on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung that has a non-slip top surface.

PP. Hardware:

1. Screws:
 - a. For Galvanized-Steel Materials: Self-tapping, hex-head, [zinc-plate steel][or][300 series stainless steel] screws with a neoprene gasket encapsulated by a [zinc-plate steel][or][300 series stainless steel] washer.
 - b. For Aluminum and Stainless Steel Materials: Self-tapping, hex-head, 300 series stainless steel screws with a neoprene gasket encapsulated by a 300 series stainless steel washer.
 - c. Provide protective covers on exposed screws to prevent personnel injury.
2. Bolts, Nuts, and Washers:
 - a. For Joining Galvanized and Painted Carbon Steel Materials: Hex-head, high-strength, [galvanized steel][or][300 series stainless steel].
 - b. For Joining Aluminum and Stainless Steel Materials: Hex-head, high-strength, 300 series stainless steel.

- c. Use washers and lock washers at each bolted connection.
- d. Select bolt size and spacing sufficient for load and application.

QQ. Welding:

- 1. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
 - a. Use welding materials with corrosion properties equal to material being welded.
- 2. Use welders that are certified to weld at least **[twice]** the thickness of the material to be welded. Certification shall be within **[three][six]<Insert number>** months of work being performed.
- 3. Welds shall be continuous, full-penetration welds unless otherwise indicated. Intermittent welds, stitch welds, and tack welds are permitted only in specific applications indicated.
- 4. Use welders and welding procedures complying with the following:
 - a. Piping Systems: Section IX of the ASME Boiler and Pressure Vessel Code and Section V of ASME B31.1.
 - b. Structural Aluminum: AWS D1.2/D1.2M.
 - c. Structural Carbon Steel: AWS D1.1/D1.1M.
 - d. Structural Stainless Steel: AWS D1.6/D1.6M.
 - e. Sheetmetal: AWS D9.1/D9.1M.

RR. Painting:

- 1. General:
 - a. Painted OEM components do not require additional coating other than touchup to damaged areas. Match the touchup coating to surrounding undamaged surfaces.
 - b. Finish miscellaneous surfaces to match continuous surfaces.
 - c. Protect mill galvanized surfaces that are exposed to view, such as raw steel cuts and damage by welding, with multiple coats of matching galvanized paint.
 - d. Protect mill galvanized surfaces that are concealed, such as raw steel cuts and damage by welding, with multiple coats of zinc-rich paint or matching galvanized paint.
 - e. Touch up or entirely repaint surface finishes, damaged during shipment and installation, to the original condition, using original materials and methods.
- 2. Preparation:
 - a. Submit proposed manufacturer's written preparation and application instructions for information.
 - b. If paint manufacturer's recommended preparation requirements differ from those indicated, use the more stringent requirements.
 - c. Structural carbon steel to be painted shall be deburred, ground smooth, cleaned, and blasted in accordance with **[SSPC-SP 6/NACE No. 3][or][SSPC-SP 10/NACE No. 5]**.
 - d. Before applying a primer and a finish coat, remove oil and grease from surfaces to be coated using clean rags soaked in thinner in accordance with SSPC-SP 1.
 - e. Treat surfaces to be painted to ensure that paint adheres.
- 3. Primer:
 - a. Rust-inhibiting type, with a minimum dry film thickness of **[1][2]<Insert value>** mil(s) per coat.
 - b. Apply at least **[two]<Insert number>** coats of primer to unfinished carbon steel surfaces and at least one coat of primer to other surfaces.
 - c. Use primer that is compatible with substrate and finish coat.

4. Finish Coat:
 - a. Finish coat painting system shall be **[alkyd-enamel][epoxy][polyurethane]<Insert coating>**.
 - b. Use dry film thickness recommended by paint manufacturer for each coat. Total dry film thickness of all finish coats not less than **[3][5]<Insert value>** mils.
 - c. Painted Surfaces Minimum Properties:
 - 1) Salt Spray ASTM B117: 5 percent salt solution fog at **95 deg F (35 deg C)** for **[500][1000][2000]** hours with no deterioration.
 - 2) Adhesion ASTM D3359: When the coating is cut into **0.0625-inch (1.6-mm)** squares and 3M No. 600 tape is suddenly removed, there is no loss of adhesion.
 - 3) Acid Resistance ASTM D3260: 15-minute exposure to 10 percent hydrochloric acid at room temperature with no effect.
 - 4) Alkali Resistance ASTM D1647: 15-minute exposure to 10 percent sodium hydroxide at room temperature with no effect.
 - 5) Humidity Resistance ASTM D2247: 850-hour exposure to **100 deg F (38 deg C)** and at least 95 percent relative humidity with no effect.
 - 6) Pencil Hardness ASTM D3363: A hardness of 1H.
 - d. Finish coat color shall be selected by Architect and not be limited to manufacturer's standard offering.
 - 1) Submit a written request for color selection and indicate in the request the date color selection must be returned without impacting schedule.
5. Application: Paint the following surfaces with primer and finish coat indicated:
 - a. Unfinished carbon steel surfaces.
 - b. Exposed mill galvanized-steel surfaces of air-handling unit casing exterior.
 - c. Exposed aluminum surfaces of air-handling unit casing exterior.
 - d. Exposed stainless steel surfaces of air-handling unit casing exterior.

SS. Cleanliness Requirements:

1. General:
 - a. Provide equipment that has been manufactured, shipped, stored, and installed maintaining highest degree of cleanliness possible.
 - b. Owner Cleanliness Inspection: Air-handling unit(s) cleanliness is subject to Owner cleanliness inspection **[and must pass a white glove test]** before packaging for shipment.
 - c. **<Insert requirements>**.
2. During Manufacturing:
 - a. Clean materials to be free of mill grease, oxidation, dirt, dust, and other impurities before manufacturing and assembly.
 - b. Protect casing materials from contamination during manufacturing and assembly.
 - c. Use sealing materials that do not outgas.
 - d. Provide OEM components and equipment from their respective manufacturers free of grease, oxidation, and dirt. Store OEM components and equipment indoors. Cover and protect OEM components and equipment to maintain cleanliness. Follow OEM instructions for equipment storage.
3. After Manufacturing:

- a. Before shipment, after unit is completely assembled, clean unit inside and out.
 - 1) Vacuum entire inside to remove dirt, dust, and debris using HEPA-filtered vacuum equipment.
 - 2) Purge hard to reach surfaces with dry, oil-free, compressed or bottled nitrogen.
 - 3) Wipe down all surfaces, inside and out, with a residue-free cleaning agent.
- b. Protect unit to maintain cleanliness.
4. Shipping:
 - a. Protect interior and exterior of air-handling unit from exposure to weather dirt, dust, and debris during shipment and rigging.
 - b. Cover openings with puncture-resistant durable coverings to ensure that cleanliness is maintained inside unit while providing an air- and watertight seal.
5. On-Site Storage:
 - a. If air-handling unit is to be stored before installation, Installer shall work closely with air-handling unit manufacturer for air-handling unit manufacturer to provide adequate protection at the factory to ensure that cleanliness for both unit interior and unit exterior is maintained. This protection shall remain in place until unit startup is performed.
 - b. For extended periods of storage, provide a means to rotate fan and motor assemblies on a periodic basis (as recommended by manufacturer) without compromising unit cleanliness.

TT. Accessories:

1. Tool Kit:
 - a. Manufacturer shall assemble a tool kit specially designed for use in servicing air-handling units furnished.
 - b. Include only special tools required to service air-handling unit components not readily available for purchase by Owner service personnel in performing routine maintenance.
 - c. Place tools in a lockable case with hinged cover.
 - d. Mark case cover with large and permanent text to indicate special purpose of tool kit, such as "Air-Handling Unit Tool Kit." Text size shall be at least **[1 inch (25 mm)]<Insert dimension>** high.
 - e. Provide a list of each tool furnished and permanently attach the list to underside of case cover. Text size shall be at least **[1 inch (25 mm)]<Insert dimension>** high.

2.5 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. AHRI 260 (I-P): Air-handling unit sound ratings shall be in accordance with AHRI 260 (I-P), "Sound Rating of Ducted Air Moving and Conditioning Equipment."
2. AHRI 261 (SI): Air-handling unit sound ratings shall be in accordance with AHRI 261 (SI), "Sound Rating of Ducted Air Moving and Conditioning Equipment."
3. AHRI 410: Air-handling unit coils shall be rated in accordance with AHRI 410 and shall be listed by AHRI **[and labeled in accordance with AHRI]**.
4. AHRI 1060 (I-P) Certification: Air-handling units that include **[energy wheels][fixed plate heat exchangers][and][heat pipe heat exchangers]** shall be rated in accordance with AHRI 1060 (I-P) and shall be listed by AHRI **[and labeled in accordance with AHRI]**.
5. AHRI 1061 (SI) Certification: Air-handling units that include **[energy wheels][fixed plate heat exchangers][and][heat pipe heat exchangers]** shall be rated in accordance with AHRI 1061 (SI)

and shall be listed by AHRI[**and labeled in accordance with AHRI**].

B. AMCA Compliance:

1. AMCA 201: Air-handling unit manufacturer shall evaluate fan's performance within the air-handling unit in accordance with AMCA 201, "Fans and Systems" and account for conditions within the air-handling unit that could be detrimental to fan's performance by adjusting the fan performance indicated on Drawings.
2. AMCA 205 Certification: Air-handling unit fan's fan efficiency grade (FEG) shall be rated in accordance with AMCA 205, "Energy Efficiency Classifications for Fans"[**and shall bear the AMCA-certified FEG seal**].
3. AMCA 210 Certification: Air-handling unit fan's air performance shall be rated in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating"[**and shall bear the AMCA-certified air ratings seal**].
4. AMCA 300: Air-handling unit fan's sound performance shall be rated in accordance with AMCA 300, "Reverberant Room Method for Sound Testing of Fans."
5. AMCA 301 Certification: Air-handling unit fan's sound performance shall be rated in accordance with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data"[**and shall bear the AMCA-certified sound ratings seal**].
6. AMCA 500-D: Air-handling unit damper's performance shall be rated in accordance with AMCA 500-D, "Laboratory Methods of Testing Dampers for Rating"[**and shall bear the AMCA-certified air ratings seal**].

C. NFPA Compliance:

1. NFPA 70: Electrical components, devices, and accessories shall be listed and labeled by a qualified testing agency, and marked for intended location and application.
2. NFPA 90A: Design, fabrication, and installation of air-handling units and components shall comply with NFPA 90A.

D. UL Compliance:

1. UL 1598 Certification: Air-handling unit UVGI shall be NRTL listed and labeled in accordance with UL 1598, "Luminaires."
2. UL 1995 Certification: Where indicated, air-handling unit components shall be NRTL listed and labeled in accordance with UL 1995, "Standard for Safety Heating and Cooling Equipment."

2.6 SOURCE QUALITY CONTROL - INDEPENDENT LABORATORY TESTING

A. General:

1. Project-specific testing by an independent laboratory is not required if air-handling unit manufacturer has written independent laboratory test results of past tests performed on same casing construction proposed for use on this Project.
2. If Project-specific testing is required, testing shall be performed in ample time to include test reports with submittals and before manufacturing of air-handling units. Include sufficient lead time for unit delivery, installation, and testing required by construction schedule.

B. Casing Structural Deflection Test:

1. Include service of an independent testing laboratory to verify casing structural deflection requirements indicated.
 - a. In lieu of independent laboratory testing, manufacturer may perform factory deflection

testing of proposed construction to prove compliance if witnessed by **[Architect][and][Owner]**. Manufacturer shall bear cost of labor and travel expenses to witness testing.

2. Test casing construction to performance criteria indicated.
3. Test casing construction proposed for use on Project. Include, at a minimum, particulars such as metal materials and thickness, internal support and reinforcing, and insulation material and thickness.
4. Test largest full-size casing panel proposed for use on Project.
5. Test proposed construction of walls, floor, and roof. Include a separate test for each unique casing construction proposed.
6. Submit test reports for each test to show compliance with performance indicated.

C. Casing Airborne Sound Transmission Test:

1. Include services of an independent testing laboratory to test proposed casing construction for sound transmission. Include a separate test for each unique casing construction proposed.
2. Conduct tests in accordance with ASTM E90.
3. Determine sound transmission class by using ASTM E413.
4. Test proposed construction of walls and roof.
5. Test proposed construction of floor assembly only if air-handling unit is not installed on a concrete housekeeping pad or building structural floor.
6. Submit test reports for each test to show compliance with performance indicated.

D. Casing Sound Absorption Test:

1. Include services of an independent testing laboratory to verify casing sound absorption coefficients for perforated casing panels. Provide a separate test for each unique casing construction proposed.
2. Conduct tests in accordance with ASTM C423 and ASTM E795.
3. Test proposed construction of walls and roof.
4. Submit test reports to show compliance with performance indicated.

2.7 SOURCE QUALITY CONTROL - AIR-HANDLING UNIT FACTORY TESTS

A. Witness of Testing: Allow **[Architect][Commissioning Agent][Construction Manager][and][Owner]<Insert entity>** access to place where air-handling units are being tested for witness testing.

1. Submit written notification at least **[30][20]<Insert number>** days in advance of testing.
2. Schedule testing at mutually agreeable dates and times.

B. Witness Testing Travel Expenses:

1. Include in bid, the cost of travel expenses to witness factory testing. Total cost for travel expenses shall be clearly indicated separately in bid.
2. Expenses shall include roundtrip **[coach][or][first]** class airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation and parking, and all associated taxes and fees.
3. Exclude other incidental expenses not indicated.
4. Include travel expenses for **[one][two]<Insert number>** representative(s) with origin of **<Insert city and state>**.

C. Casing Leakage Test:



1. Perform a leak test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and arrangement]<Insert requirement>**.
2. Follow testing procedures in accordance with ASHRAE 111.
3. Perform leak test before shipping first air-handling unit **[of unique size and arrangement]**.
4. Test results shall indicate that units comply with leakage requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
5. Prepare test reports in accordance with ASHRAE 111.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

D. Casing Structural Deflection Test:

1. Perform a structural deflection test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and arrangement][only one air-handling unit with the worst-case condition]<Insert requirement>**.
2. Pressurize and load air-handling units to the performance criteria indicated for structural deflection. Test air-handling unit **[floors][walls and roofs]**.
3. Test results shall indicate that units comply with deflection requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
4. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

E. Functional Run Test:

1. Run test each unit before shipment.
2. Test and balance fans to comply with vibration requirements indicated.
3. Energize each electrical device to ensure that it is operational.
 - a. Take meter readings for volts, amperes, and kVAr on each phase leg of each motor.
 - b. Take meter readings for volts, amperes, and kVAr on each single-phase power connection to field power.
4. Exercise each damper to ensure proper operation.
5. Exercise each access door to ensure proper fit.
6. Exercise each valve to ensure proper operation.
7. Submit a written report for each unit tested. Written report shall include, at a minimum, full name of each person witnessing test, detailed list of each unit component tested, condition observed, and corrective action required. Each line item shall have full name of the person doing the checkout and date and time the checkout was performed.

F. Fan Vibration Test:

1. Perform a fan vibration test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Energize each fan within the air-handling unit after air-handling unit final assembly and perform a vibration analysis with fan operating at design speed **[and at all speeds throughout the range from design to minimum speed]**.

3. Three vibration measurements shall be taken for each bearing in horizontal, vertical, and axial directions. Vibration measurements shall be recorded and consist of vibration amplitude verses frequency[**with filter-in**].
4. Fan bearing measurement points shall be marked or scribed on bearings for permanent record.
5. Test results shall indicate that units comply with vibration requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

G. Acoustical Performance Test:

1. Perform an acoustical performance test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Air-handling unit acoustic performance shall be verified by factory test in accordance with AHRI 260 (I-P) and AHRI 261 (SI).
3. Air-handling unit supply-air discharge, return-air inlet, and casing radiated sound components shall be measured with air-handling unit operating at design conditions.
4. Testing Location: Perform testing in a location complying with AHRI 220, "Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment."
 - a. Test location shall be broadband qualified in accordance with AHRI 220 Section 5.1 and discrete frequency qualified in accordance with Section 5.2.
5. Operating conditions used in acoustic testing shall be verified by test in accordance with AMCA 210[**in an AMCA-accredited facility**].
6. Test results shall indicate that units comply with acoustical requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
7. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

H. Airflow Capacity Performance Test:

1. Perform an airflow capacity performance test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Operating conditions shall be verified by test in accordance with AMCA 210[**in an AMCA-accredited facility**].
3. Test results shall indicate that units comply with design airflow requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
4. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

2.8 SOURCE QUALITY CONTROL - OEM COMPONENT FACTORY TESTS

A. Air Mixer Testing:

1. Owner-witnessed performance test to demonstrate compliance with performance requirements indicated.

B. Coil Testing:

1. Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
2. Refrigerant Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
3. Steam Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than to **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
4. Coils to display a tag with inspector's identification as proof of testing.

C. Fan Vibration Testing:

1. Perform a fan vibration test for **[each fan]<Insert requirement>**.
2. Energize each fan after final assembly and perform a vibration analysis with fan operating at design speed **[and at all speeds throughout the range from design to minimum speed]**.
3. Three vibration measurements shall be taken for each bearing in horizontal, vertical, and axial directions. Vibration measurements shall be recorded and consist of vibration amplitude verses frequency **[with filter-in]**.
4. Fan bearing measurement points shall be marked or scribed on bearings for permanent record.
5. Test results shall indicate that units comply with vibration requirements indicated. Make changes to noncompliant fans and retest until fans comply with requirements.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single fan, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine air-handling units before installation. Reject units with physical damage, and air-handling unit components that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for the following before installation of air-handling units:
 1. Structural substrate mounting and anchorage to verify actual sizes, types, and locations.
 2. Piping systems to verify actual sizes, types, and locations of connections.
 3. Ductwork and plenums to verify actual sizes, types, and locations of connections.
 4. Electrical services and controls to verify actual sizes, types, and locations of connections.

- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF INDOOR, CUSTOM AIR-HANDLING UNITS

- A. Equipment Mounting: Install air-handling units at locations indicated on Drawings. Unless, otherwise indicated on Drawings, install air-handling units on concrete equipment bases.
1. Units Mounted on Concrete Bases:
 - a. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - b. Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material.
 - c. Fill voids between air-handling unit bases and concrete bases using high-strength non-shrink grout.
 - d. Continuously seal between concrete bases and perimeter of air-handling unit bases with nonhardening sealant.
 2. Units Mounted to Structural-Steel Supports: Level unit air-handling bases using aluminum or stainless steel shims compatible with air-handling unit base material. Continuously seal between structural supports and air-handling unit bases with nonhardening sealant.
 3. Units Mounted Directly to Finished Floors: Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material. Continuously seal between floor and perimeter of air-handling unit bases with nonhardening sealant.
 4. Suspended Units: Suspend and laterally brace air-handling units from building structure by attaching to only air-handling unit bases at manufacturer-designated locations.
 5. Comply with requirements for seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Equipment Clearances and Access:
1. Arrange installation of air-handling units to provide access space around air-handling units for service and maintenance and for removal and replacement of internal components.
 2. Provide clearance and access required by governing codes and NFPA 70.
 3. At a minimum, comply with requirements indicated on Drawings and air-handling unit manufacturer's written instructions.

3.3 PROTECTION DURING CONSTRUCTION

- A. Exterior Covers: Cover air-handling units during construction with sealed covers to protect air-handling unit casing and externally mounted components from physical damage, dirt, dust and debris, paint splatter, and any other construction materials.
1. Minor physical damage, as determined by Owner, shall be repaired by air-handling unit factory service personnel to factory-finished condition.
 2. Replace air-handling units with damage that in any way compromises the performance indicated.
- B. Internal Access: Keep access doors locked to maximum extent possible and restrict access to only authorized personnel.
1. Open access doors only during periods authorized work inside air-handling units is required.
 2. Coordinate and monitor work inside air-handling units on a shift basis. Lock access doors once work is complete or at the end of each shift.

3. Immediately report unauthorized access and any observed damage to Owner.

3.4 DUCT CONNECTIONS

- A. Connect ducts and plenums to air-handling unit connections. Comply with requirements in Section 233113 "Metal Ducts."
- B. Connect ducts and plenums to air-handling unit connections with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- C. Provide duct transitions required to make field connections to air-handling units.
- D. Arrange ducts and plenums to provide unobstructed access to inside of air-handling units.

3.5 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, provide unobstructed access to inside of air-handling units for service and maintenance.
- C. Connect piping to air-handling units with flexible connectors.
- D. Drain Pan Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
 1. Make connections to air-handling unit connections with **[flanges or]**unions.
 2. Extend **[dedicated]**drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
 3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
 4. Install threaded cleanouts at changes in direction.
 5. Secure drain piping to structure.
- E. Air-Handling Unit Floor Drains: Do not require installation of permanent drain piping.
- F. Air-Handling Unit Floor Drain Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
 1. Make connections to air-handling unit connections with **[flanges or]**unions.
 2. Extend **[dedicated]**drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
 3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
 4. Install threaded cleanouts at changes in direction.
 5. Secure drain piping to structure.
- G. Chilled-Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

1. Comply with requirements indicated on Drawings.
 2. Make connections to coils with a [flange][or][union].
 3. Connect to each coil inlet with shutoff valve, test plug, [pressure gauge][and][thermometer].
 4. Connect to each coil outlet with balancing valve, test plug, [pressure gauge][thermometer][flow meter][and][shutoff valve].
 5. Connect each coil drain connection with a drain valve, which is full size of drain connection.[
Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.]
 6. Connect each coil vent connection with [automatic][or][manual] vent, which is full size of vent connection.
- H. Hot-Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
1. Comply with requirements indicated on Drawings.
 2. Make connections to coils with a [flange][or][union].
 3. Connect to each coil inlet with shutoff valve, test plug, [pressure gauge][and][thermometer].
 4. Connect to each coil outlet with balancing valve, test plug, [pressure gauge][thermometer][flow meter][and][shutoff valve].
 5. Connect each coil drain connection with a drain valve, which is full size of drain connection.[
Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.]
 6. Connect each coil vent connection with [automatic][or][manual] vent, which is full size of vent connection.
- I. Steam and Condensate Coil Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap assembly, and union or flange at each coil return connection.
- J. Refrigerant Coil Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve at each supply and return connection.
- K. Steam Humidifier Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install gate valve and inlet strainer at supply connection of steam humidifiers and steam trap assemblies to condensate return connection.

3.6 ELECTRICAL CONNECTIONS

- A. Install field power to each air-handling unit electrical power connection. Coordinate with air-handling unit manufacturer and installers.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553

"Identification for Electrical Systems."

2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert dimension> high.

3.7 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.8 STARTUP SERVICE

- A. Engage an air-handling unit factory[-**authorized**] service representative to perform startup service.
 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Verify that shipping, blocking, and bracing are removed.
 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, controls, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 6. Verify that face-and-bypass dampers provide full face flow.
 7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
 8. Comb coil fins for parallel orientation.
 9. Verify that proper thermal-overload protection is installed for electric heaters.
 10. Install new, clean filters.
 11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
 12. <Insert requirement>.
- B. Starting procedures for air-handling units include the following:
 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. [**Replace fan and motor pulleys as required to achieve design conditions.**]
 2. Measure and record motor electrical values for voltage and amperage.
 3. Manually operate dampers from fully closed to fully open position and record fan performance.
 4. <Insert requirement>.
- C. Heat Wheel Startup Service:
 1. After field installation is complete, a final checkout and startup shall be completed to ensure proper purge adjustment, seal adjustment, control settings, and other key operational functions.
 2. Service shall be completed by trained factory service personnel employed by heat wheel manufacturer.
 3. Submit a report summarizing findings, adjustments made, and final settings.

3.9 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Before turning equipment over to Owner for use, adjust air-handling unit components that require further adjustment for proper operation. Consult air-handling unit manufacturer for instruction.
- D. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.
- E. Seasonal Adjustments: Make seasonal visits during warranty period to inspect and review operation of equipment. Make necessary adjustments for components observed to require adjustments for proper operation. Prepare and submit a report to Owner documenting each visit, observations, and any adjustments made.

3.10 CLEANING

- A. Cleaning Schedule: After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before Owner use, clean air-handling units to remove foreign material and construction dirt and dust.
- B. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.
 - 1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
 - 2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
 - 3. Clean all internal components, such as, coils, dampers, filter frames, fans, and motors.
 - 4. Clean light fixtures and control devices.
- C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt, and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.
- D. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.
- E. Acceptance: Following unit cleaning, submit a written request for review and [Owner] acceptance. Acceptance for cleaning of air-handling units [**with absolute filters**] must pass a white glove test.

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: [**Owner will engage**][**Engage**] a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections: Perform the following tests and inspections[**with the assistance of a factory-**

authorized service representative]:

1. After field piping connections are complete, test **[hydronic][and][steam]** coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Field-Assembly Supervision: Instruct Installer and supervise field installation of **[first]<Insert quantity>** air-handling unit(s) shipped in multiple pieces for field assembly.
4. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Field Casing Leakage Test:

1. Perform leak testing of air-handling units that include field assembly of multiple sections. Air-handling units that are shipped and installed as a single piece do not require field testing.
2. Leak test **[one]<Insert value>** air-handling unit(s) of each unique size and arrangement randomly selected by **[Architect][Commissioning Agent][Owner]**.
3. Follow procedures complying with ASHRAE 111.
4. Assembled air-handling units shall satisfy leakage criteria indicated. Modify air-handling units that fail to satisfy criteria and retest. For every air-handling unit that fails test, another air-handling unit shall be tested until all air-handling units tested pass leakage criteria on first attempt.
5. Submit a test report for each test indicating test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.
6. Test report shall be in accordance with ASHRAE 111.
7. Witness Testing:
 - a. Provide written notification at least **[30][20]<Insert number>** business days in advance of testing.
 - b. Testing shall be conducted in presence of testing and balancing agent.
 - c. Other parties such as Architect, Commissioning Agent, and Owner shall be invited to witness testing with attendance being optional.

E. Field Fan Vibration Test:

1. Perform fan vibration testing for every one out of **[10]<Insert number>** air-handling unit fans randomly selected by **[Architect][Commissioning Agent][Owner]**.
2. Test after air-handling unit installation is complete.
3. Three vibration readings shall be taken for each bearing in horizontal, vertical, and axial directions. Record each reading including vibration amplitude verses frequency.
4. Modify fans that fail to satisfy performance criteria and retest. For every fan that fails test, another fan shall be tested until all fans tested pass criteria on first attempt.
5. Submit a report for each fan tested indicating air-handling unit designation, fan designation, test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.
6. Witness Testing:
 - a. Provide written notification at least **[30][20]<Insert number>** business days in advance of testing.
 - b. Testing shall be conducted in presence of testing and balancing agent.
 - c. Other parties such as Commissioning Agent, Architect, and Owner shall be invited to witness testing with attendance being optional.

- F. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

- G. Prepare test and inspection reports.

3.12 OPERATION DURING CONSTRUCTION

- A. Operation of air-handling units for temporary cooling, heating, and ventilation is not allowed without Owner authorization.
1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:
 - a. Description of construction activities while units are operating.
 - b. Operation:
 - 1) Beginning and ending calendar dates.
 - 2) List each day during week.
 - 3) List start and stop time and hours for each day.
 - c. Startup procedures and shut-down procedures.
 - d. Provisions for routine monitoring of unit operation.
 - e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage, and current and electrical fault.
 - f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
 - g. Record keeping.
 2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least **[two]<Insert number>** years after the warranty indicated expires.
 3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner.
- B. Filtration during Temporary Use:
1. Protect air-handling system ducts (exhaust air, outdoor air, and return air) with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV **[8][11][13]<Insert MERV>** in accordance with ASHRAE 52.2.
 2. Protect air-handling units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV **[8][11][13]<Insert MERV>** in accordance with ASHRAE 52.2.
 3. Do not operate air-handling units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
 4. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting, and balancing.
- C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.13 DEMONSTRATION

- A. Engage air-handling unit manufacturer **[employed training instructor][or][factory-authorized service**

representative] to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

- B. Training shall include, but not be limited to, procedures and schedules related to performance, safety, startup and shut down, troubleshooting, servicing, preventive maintenance, and how to obtain replacement parts.
1. Access Doors: Adjustment, gasket removal and replacement, handle removal and replacement, and spare parts.
 2. Access Panels: Removal and replacement, adjustment, gasket removal and replacement, and spare parts.
 3. Air Blenders: Cleaning, operation, removal, and replacement.
 4. Coils: Cleaning, combing fins, draining, venting, removal, and replacement.
 5. Controls: Calibration, cleaning, operation, service, removal and replacement, and spare parts.
 6. Damper Assemblies: Cleaning, operation, service, removal and replacement, and spare parts.
 7. Drain Pans: Cleaning, removal, and replacement.
 8. Duct Silencers: Cleaning, removal, and replacement.
 9. Electric Heaters: Cleaning, operation, service, removal and replacement, and spare parts.
 10. Heat Wheels: Cleaning, operation, service, removal and replacement, and spare parts.
 11. Fan and Motor Assemblies: Cleaning, operation, removal and replacement, service, and spare parts.
 12. Filters: Operation, removal and replacement, frame gasket removal and replacement, clip removal and replacement, and spare parts.
 13. Fixed Plate heat Exchangers: Cleaning, removal, and replacement.
 14. Heat Pipe Heat Exchangers: Cleaning, combing fins, removal, and replacement.
 15. Humidifiers: Cleaning, operation, service, removal and replacement, and spare parts.
 16. UV-C Lamp Systems: Cleaning, operation, service, removal and replacement, and spare parts.
 17. Lights, Receptacles, and Switches: Cleaning, operation, service, removal and replacement, and spare parts.
 18. **<Insert requirement>**.
- C. Instructor:
1. Instructor shall be factory trained and certified by air-handling unit manufacturer with current training on equipment installed.
 2. Instructor's credentials shall be submitted for review by **[Architect][Commissioning Agent][Owner]** before scheduling training.
 3. Instructor(s) **[primary][sole]** job responsibility shall be Owner training.
 4. Instructor(s) shall have not less than **[three]<Insert number>** years of training experience with air-handling unit manufacturer and past training experience on at least **[three]<Insert number>** projects of comparable size and complexity.
- D. Schedule and Duration:
1. Schedule training with Owner at least **[20]<Insert number>** business days before first training session.
 2. Training shall occur before Owner occupancy.
 3. Training shall be held at mutually agreed date and time during normal business hours.
 4. Each training day shall not exceed **[eight]<Insert number>** hours of training. Daily training schedule shall allow time for a **[one]<Insert number>**-hour lunch period and **[15]<Insert number>**-minute break after every **[two]<Insert number>** hours of training.
 5. Perform not less than **[eight][16][24]<Insert number>** hours of training.
- E. Location: Owner to provide a suitable on-site location to host classroom training.



- F. Training Attendees: Assume [three]<Insert number> people.
- G. Training Attendance Records: For record purposes, document training attendees at start of each new training session. Record date, time, brief description of training covered during the session, attendee's name, signature, phone number, and e-mail address. Submit scanned copy of sign-in sheet to Owner for each training session.
- H. Training Format: Individual training modules to include classroom training followed by hands-on field demonstration and training.
- I. Training Materials: Provide training materials in electronic format to each attendee.
 - 1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
- J. Training Video Recording: Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- K. Written Acceptance: Obtain [Architect][Commissioning Agent][or][Owner] written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 23 73 13 00B



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 73 13 00	07 72 00 00	Roof Accessories
23 73 13 00	23 73 00 00	Indoor, Indirect, Gas-Fired Heating and Ventilating Units
23 73 13 00	23 73 00 00a	Indoor, Direct-Fired Heating and Ventilating Units



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 74 00 00 - OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Outdoor, semi-custom air-handling units.

1.2 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include dampers, including housings, linkages, and operators.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each outdoor, semi-custom air-handling unit.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of outdoor, semi-custom air-handling units, as well as procedure and diagrams.
4. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For vibration isolation[, **supports,][and seismic restraints] indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.**

1. Design Calculations: Calculate requirements for selecting vibration isolators[, **supports**,][and **seismic restraints**,] and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty.
- C. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Restraint of internal components.
- D. Wind Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Source quality-control reports.
- F. Startup service reports.
- G. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: **[One]<Insert number>** set(s) for each air-handling unit.
 2. Gaskets: **[One]<Insert number>** set(s) for each access door.
 3. Fan Belts: **[One]<Insert number>** set(s) for each air-handling unit fan.

1.6 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Entire Unit: Manufacturer's standard but not less than **[one]<Insert number>** year(s) from date of Substantial Completion.
 2. Warranty Period for Heat Wheels: Not less than **[five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[, **supports**], and **seismic restraints**, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Structural Performance:
1. Casing Panels: Self-supporting and capable of withstanding positive/negative **[8-inch wg (2000-Pa)]<Insert value>** internal static pressure, without exceeding a midpoint deflection of **[0.0042 inch/inch (0.0042 mm/mm)]<Insert dimensions>** of panel span.
 2. Floor and Roof Panels: Self-supporting and capable of withstanding **300-lb (136-kg)** static load at midspan, without exceeding a midpoint deflection of **[0.0042 inch/inch (0.0042 mm/mm)]<Insert dimensions>**.
 3. Roof Panels: Self-supporting and capable of withstanding a static snow load of **30 lb/sq. ft. (146 kg/sq. m)**, without exceeding a midpoint deflection of **[0.0042 inch/inch (0.0042 mm/mm)]<Insert dimensions>**.
- G. Casing Leakage Performance: ASHRAE 111, **[Class 6 leakage]<Insert leakage class>** or better at **[plus or minus 8-inch wg (2000 Pa)]<Insert pressure>**.
- H. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Component Importance Factor: **[1.5][1.0]**.

3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>.**

- I. Wind Performance: Air-handling units are to withstand the effects of wind determined in accordance with [ASCE/SEI 7] <Insert requirement>. See [Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]

2.2 CAPACITIES AND CHARACTERISTICS

A. Supply Fan:

1. Type: [DWDI, backward-inclined centrifugal fan][DWDI, forward-curved centrifugal fan][DWDI, airfoil centrifugal fan][SWSI, airfoil unhooused centrifugal fan] <Insert fan type>.
2. Class: AMCA 99, Section 14, [Class I][Class II][Class III].
3. Drive: [V-belt][Direct].
4. Number of Fan Wheels: <Insert number>.
5. Fan Diameter: <Insert value> inches (mm).
6. Airflow: <Insert value> cfm (L/s).
7. Total Static Pressure: <Insert value> inches wg (kPa).
8. External Static Pressure: <Insert value> inches wg (kPa).
9. Speed: <Insert rpm>.
10. Maximum Outlet Velocity: <Insert value> fpm (m/s).
11. Motor:
 - a. Size: <Insert horsepower>.
 - b. Speed: <Insert rpm>.
 - c. Volts: [208][230][460] <Insert value> V.
 - d. Phase: [Three] <Insert value>.
 - e. Hertz: [60] <Insert number> Hz.
 - f. Full-Load Amperes: <Insert value> A.
 - g. Minimum Circuit Ampacity: <Insert value> A.
 - h. Maximum Overcurrent Protection: <Insert amperage> A.

12. Fan Discharge Sound Power, dB:

- a. 1st Octave: <Insert value>.
- b. 2nd Octave: <Insert value>.
- c. 3rd Octave: <Insert value>.
- d. 4th Octave: <Insert value>.
- e. 5th Octave: <Insert value>.
- f. 6th Octave: <Insert value>.
- g. 7th Octave: <Insert value>.
- h. 8th Octave: <Insert value>.

B. Fan: [Return][Exhaust].

1. Type: [DWDI, backward-inclined centrifugal fan][DWDI, forward-curved centrifugal fan][DWDI, airfoil centrifugal fan][SWSI, airfoil unhooused centrifugal plenum fan] <Insert fan type>.
2. Class: AMCA 99, Section 14, [Class I][Class II][Class III].
3. Drive: [V-belt][Direct].
4. Number of Fan Wheels: <Insert value>.
5. Fan Diameter: <Insert value> inches (mm).
6. Airflow: <Insert value> cfm (L/s).

7. Total Static Pressure: **<Insert value> inches wg (kPa).**
8. External Static Pressure: **<Insert value> inches wg (kPa).**
9. Speed: **<Insert rpm>.**
10. Maximum Outlet Velocity: **<Insert value> fpm (m/s).**
11. Motor:
 - a. Size: **<Insert value> hp.**
 - b. Speed: **<Insert value> rpm.**
 - c. Volts: **[208][230][460]<Insert value> V.**
 - d. Phase: **[Three]<Insert number>.**
 - e. Hertz: **[60]<Insert number> Hz.**
 - f. Full-Load Amperes: **<Insert value> A.**
 - g. Minimum Circuit Ampacity: **<Insert value> A.**
 - h. Maximum Overcurrent Protection: **<Insert amperage> A.**
12. Fan Inlet Sound Power, dB:
 - a. 1st Octave: **<Insert value>.**
 - b. 2nd Octave: **<Insert value>.**
 - c. 3rd Octave: **<Insert value>.**
 - d. 4th Octave: **<Insert value>.**
 - e. 5th Octave: **<Insert value>.**
 - f. 6th Octave: **<Insert value>.**
 - g. 7th Octave: **<Insert value>.**
 - h. 8th Octave: **<Insert value>.**

C. Preheat Coil:

1. Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
2. Entering-Air Temperature: **<Insert value> deg F (deg C).**
3. Leaving-Air Temperature: **<Insert value> deg F (deg C).**
4. Face Area: **<Insert value> sq. ft. (sq. m).**
5. Maximum Face Velocity: **<Insert value> fpm (m/s).**
6. Maximum Air-Side, Static-Pressure Drop: **<Insert value> inches wg (Pa).**
7. Fin Spacing: Maximum **<Insert number> fins per inch (per mm).**
8. Minimum Number of Rows: **<Insert number>.**
9. Integral Face-and-Bypass Dampers: **[Horizontal][Vertical], opposed-blade, [galvanized-steel][aluminum][extruded-aluminum] dampers with [zinc-plated]steel operating rods rotating in sintered bronze or nylon bearings mounted in a single [galvanized-steel][aluminum][extruded-aluminum] frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.**
10. Water:
 - a. Water Flow: **<Insert value> gpm (L/s).**
 - b. Maximum Water Pressure Drop: **<Insert value> feet of head (kPa).**
 - c. Entering-Water Temperature: **<Insert value> deg F (deg C).**
 - d. Leaving-Water Temperature: **<Insert value> deg F (deg C).**
 - e. Tube Velocity: **<Insert value> fpm (L/s).**
11. Steam:
 - a. Steam Flow: **<Insert value> lb/h (g/s).**
 - b. Inlet Steam Pressure: **<Insert value> psig (kPa).**
 - c. Outer-Tube Diameter: **<Insert value> inches (mm).**

D. Heating Coil:

1. Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
2. Entering-Air Temperature: **<Insert value> deg F (deg C).**
3. Leaving-Air Temperature: **<Insert value> deg F (deg C).**
4. Face Area: **<Insert value> sq. ft. (sq. m).**
5. Maximum Face Velocity: **<Insert value> fpm (m/s).**
6. Maximum Air-Side, Static-Pressure Drop: **<Insert value> inches wg (Pa).**
7. Number of Rows: **<Insert number>.**
8. Fin Spacing: Maximum **<Insert number> fins per inch (per mm).**
9. Water:
 - a. Water Flow: **<Insert value> gpm (L/s).**
 - b. Maximum Water Pressure Drop: **<Insert value> feet of head (kPa).**
 - c. Entering-Water Temperature: **<Insert value> deg F (deg C).**
 - d. Leaving-Water Temperature: **<Insert value> deg F (deg C).**
 - e. Tube Velocity: **<Insert value> fpm (L/s).**
10. Steam:
 - a. Steam Flow: **<Insert value> lb/h (g/s).**
 - b. Inlet Steam Pressure: **<Insert value> psig (kPa).**

E. Electric Heating Coil:

1. Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
2. Input: **<Insert kilowatts>.**
3. Volts: **[120][208][230]<Insert value> V.**
4. Phase: **[Single][Three].**
5. Full-Load Amperes: **<Insert value> A.**
6. Number of Steps: **<Insert number>.**

F. Cooling Coil:

1. Sensible Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
2. Total Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
3. Entering-Air, Dry-Bulb Temperature: **<Insert value> deg F (deg C).**
4. Entering-Air, Wet-Bulb Temperature: **<Insert value> deg F (deg C).**
5. Leaving-Air, Dry-Bulb Temperature: **<Insert value> deg F (deg C).**
6. Leaving-Air, Wet-Bulb Temperature: **<Insert value> deg F (deg C).**
7. Face Area: **<Insert value> sq. ft. (sq. m).**
8. Maximum Face Velocity: **<Insert value> fpm (m/s).**
9. Maximum Air-Side, Static-Pressure Drop: **<Insert value> inches wg (Pa).**
10. Number of Rows: **<Insert number>.**
11. Fin Spacing: Maximum **<Insert number> fins per inch (per mm).**
12. Water:
 - a. Water Flow: **<Insert value> gpm (L/s).**
 - b. Maximum Water Pressure Drop: **<Insert value> feet of head (kPa).**
 - c. Entering-Water Temperature: **<Insert value> deg F (deg C).**
 - d. Leaving-Water Temperature: **<Insert value> deg F (deg C).**
 - e. Tube Velocity: **<Insert value> fpm (L/s).**
13. Refrigerant:

- a. Refrigerant Type: <Insert refrigerant type>.

G. Prefilters:

1. Type: <Insert type>.
2. Face Dimensions, each: <Insert value> inches by inches (mm by mm).
3. Depth: <Insert value> inches (mm).
4. Number of Filters, Wide by High: <Insert number>.
5. Access Location: [Front][Back][Side][Bottom].
6. Maximum or Rated Face Velocity: <Insert value> fpm (m/s).
7. Initial Resistance: <Insert value> inches wg (Pa).
8. Recommended Final Resistance: <Insert value> inches wg (Pa).
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating: [MERV 1][MERV 2][MERV 3][MERV 4], and corresponding average arrestance according to ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: [MERV 6][MERV 13]<Insert value>, according to ASHRAE 52.2.

H. Final Filters:

1. Type: <Insert type>.
2. Face Dimensions, each: <Insert value> inches by inches (mm by mm).
3. Depth: <Insert value> inches (mm).
4. Number of Filters, Wide by High: <Insert number>.
5. Access Location: [Front][Back][Side][Bottom].
6. Maximum or Rated Face Velocity: <Insert value> fpm (m/s).
7. Initial Resistance: <Insert value> inches wg (Pa).
8. Recommended Final Resistance: <Insert value> inches wg (Pa).
9. Minimum Efficiency Reporting Value:
 - a. MERV Rating: [MERV 6][MERV 13]<Insert value>, according to ASHRAE 52.2.

I. Dampers: [Zone][Mixing dampers][Face and bypass].

J. Sound Attenuators:

1. Configuration: [Straight][Elbow].
2. Shape: [Rectangular][Round].
3. Attenuation Mechanism: [Acoustic glass fiber][Packless].
4. Maximum Pressure Drop: <Insert value> inches wg (Pa).
5. Length: <Insert value> inches (mm).
6. Face Dimension: <Insert value> inches (mm) wide by <Insert value> inches (mm) high.
7. Face Velocity: <Insert value> fpm (m/s).
8. Dynamic Insertion Loss:
 - a. 1st Octave: <Insert dBa>.
 - b. 2nd Octave: <Insert dBa>.
 - c. 3rd Octave: <Insert dBa>.
 - d. 4th Octave: <Insert dBa>.
 - e. 5th Octave: <Insert dBa>.
 - f. 6th Octave: <Insert dBa>.
 - g. 7th Octave: <Insert dBa>.
 - h. 8th Octave: <Insert dBa>.

9. Generated Noise:

- a. 1st Octave: <Insert dBa>.
- b. 2nd Octave: <Insert dBa>.
- c. 3rd Octave: <Insert dBa>.
- d. 4th Octave: <Insert dBa>.
- e. 5th Octave: <Insert dBa>.
- f. 6th Octave: <Insert dBa>.
- g. 7th Octave: <Insert dBa>.
- h. 8th Octave: <Insert dBa>.

K. Steam Grid Humidifier:

1. Humidification Rate: <Insert value> lb/h (g/s).
2. Steam Supply Pressure: <Insert value> psig (kPa).
3. Dry-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
4. Wet-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
5. Maximum Absorption Distance: <Insert value> inches (mm).
6. Number of Distribution [Tubes][Manifolds]: <Insert number>.

L. Self-Contained Electric-Resistance Humidifier.

1. Humidification Rate: <Insert value> lb/h (g/s).
2. Dry-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
3. Wet-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
4. Maximum Absorption Distance: <Insert value> inches (mm).
5. Minimum Makeup Water Supply Pressure: <Insert value> psig (kPa).
6. Electric-Resistance Evaporation Chamber:
 - a. Power Input per Chamber: <Insert number> kW.
 - b. Number of Chambers: <Insert number>.

M. Self-Contained Gas-Fired Humidifier:

1. Humidification Rate: <Insert value> lb/h (g/s).
2. Dry-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
3. Wet-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
4. Maximum Absorption Distance: <Insert value> inches (mm).
5. Minimum Makeup Water Supply Pressure: <Insert value> psig (kPa).
6. Gas-Fired Generator:
 - a. Fuel Input: <Insert value> Btu/h (kW).
 - b. Fuel Pressure: <Insert value> inches wg (kPa).
7. Number of Distribution [Tubes][Manifolds]: <Insert number>.

N. Heat-Exchanger Humidifier:

1. Humidification Rate: <Insert value> lb/h (g/s).
2. Dry-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
3. Wet-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
4. Maximum Absorption Distance: <Insert value> inches (mm).
5. Minimum Makeup Water Supply Pressure: <Insert value> psig (kPa).
6. Steam to Heat Exchanger:



- a. Supply Pressure at Control Valve: **<Insert value> psig (kPa).**
- b. Condensing Rate: **<Insert value> lb/h (g/s).**
- O. Air-to-Air Energy Recovery:
 - 1. Type: **[Heat-wheel air-to-air energy recovery][Fixed-plate air-to-air energy recovery].**
 - 2. Exhaust Air:
 - a. Airflow: **<Insert value> cfm (L/s).**
 - b. Face Velocity: **<Insert value> fpm (m/s).**
 - c. Summer:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - d. Winter:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 5) Air Pressure Drop: **<Insert value> inches wg (Pa).**
 - 3. Supply Air:
 - a. Airflow: **<Insert value> cfm (L/s).**
 - b. Face Velocity: **<Insert value> fpm (m/s).**
 - c. Summer:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - d. Winter:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 5) Air Pressure Drop: **<Insert value> inches wg (Pa).**
 - e. Wheel Drive:
 - 1) Motor Size: **<Insert horsepower>.**
 - 2) Motor Electrical Characteristics:
 - a) Volts: **[120][208][230]<Insert value> V.**
 - b) Phase: **[Single][Three].**
 - c) Hertz: **[60]<Insert number> Hz.**
 - f. Effectiveness: **<Insert percentage>.**
 - 4. Air Blender:

- a. Airflow: **<Insert value> cfm (L/s).**
- b. Minimum Velocity: **<Insert value> fpm (m/s).**
- c. Air Pressure Drop: **<Insert value> inches wg (Pa).**

5. Diffuser:

- a. Airflow: **<Insert value> cfm (L/s).**
- b. Air Pressure Drop: **<Insert value> inches wg (Pa).**

2.3 OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. **[Carrier Global Corporation]**
2. **[Coil Company, LLC]**
3. **[Daikin Applied]**
4. **[Dunham-Bush, Inc]**
5. **[Trane]**
6. **[USA Coil & Air]**
7. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
8. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Carrier Global Corporation]**
2. **[Coil Company, LLC]**
3. **[Daikin Applied]**
4. **[Dunham-Bush, Inc]**
5. **[Trane]**
6. **[USA Coil & Air]**
7. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
8. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain from single source from single manufacturer.

D. Unit Casings:

1. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.
2. Base Rail:

- a. Material: **[Galvanized steel][Welded structural steel]<Insert material>.**
- b. Height: **[6 inches (150 mm)]<Insert dimension>.**

3. Casing Joints: Hermetically sealed at each corner and around entire perimeter.
4. Double-Wall Construction:

a. Outside Casing Wall:

- 1) Material, Galvanized Steel: Minimum **[18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.**

- 2) Material, Aluminum: Minimum [16 gauge (1.3 mm)][14 gauge (1.6 mm)][12 gauge (2.0 mm)]<Insert value> thick.
 - 3) Material, Stainless Steel: Minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.
 - 4) Factory Finish: Provide [manufacturer's standard finish][corrosion-resistant coating]<Insert special coating>.
- b. Inside Casing Wall:
- 1) Material, Galvanized Steel: [Solid][Perforated], minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - 2) Material, Aluminum: [Solid][Perforated], minimum [16 gauge (1.3 mm)][14 gauge (1.6 mm)]<Insert value> thick.
 - 3) Material, Stainless Steel: [Solid][Perforated], minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - 4) Antimicrobial Coating: Applied during the manufacturing process. [EPA approved][NSF approved][FDA listed].
5. Floor Plate:
- a. Material:
- 1) Galvanized steel,[treadplate,] minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.7 mm)][10 gauge (3.5 mm)]<Insert value> thick.
 - 2) Aluminum,[treadplate,] minimum [18 gauge (1.0 mm)][16 gauge (1.3 mm)][14 gauge (1.6 mm)][12 gauge (2.0 mm)][10 gauge (2.6 mm)]<Insert value> thick.
 - 3) Stainless steel,[treadplate,] minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.5 mm)]<Insert value> thick.
- b. Antimicrobial Coating: Applied during the manufacturing process. [EPA approved][NSF approved][FDA listed].
6. Roof: Cross-broken and pitched with "C" caps over joints to provide watertight seal.
7. Piping Vestibule: Insulated with same insulation and thickness as casing, [18 inches (450 mm)][24 inches (600 mm)][30 inches (750 mm)]<Insert dimension> deep by full width of piping connections.
8. Casing Insulation:
- a. Materials: [Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071][or][injected polyurethane foam insulation].
 - b. Casing Panel R-Value: Minimum [R-6.5][R-11][R-13]<Insert value>.
 - c. Insulation Thickness: [1 inches (25 mm)][2 inches (50 mm)]<Insert dimension>.
 - d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
9. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
10. Static-Pressure Classifications:
- a. For Unit Sections Upstream of Fans: Minus [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)][6-inch wg (1500 Pa)]<Insert value>.
 - b. For Unit Sections Downstream and Including Fans: [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)][6-inch wg (1500 Pa)]<Insert value>.
11. Panels, Doors, and Windows:

- a. Panels:
 - 1) Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
 - 2) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. At least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** wide by full height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>**.
- b. Doors:
 - 1) Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
 - 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** wide by full height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>**.
- c. Windows:
 - 1) Construction: Fabricate windows in access panels and doors of double-glazed, safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
 - 2) Size: Minimum **[6 inches (150 mm)]<Insert dimension>**, square or round.
- d. Locations and Applications:
 - 1) Fan Section: Doors[, **with windows**].
 - 2) Coil Section: Panels.
 - 3) Access Section: Doors[, **with windows**].
 - 4) Access Sections Immediately Upstream and Downstream of Coil Sections: Doors[, **with windows**].
 - 5) Damper Section: Doors[, **with windows**].
 - 6) Filter Section: **[Doors][Panels]** large enough to allow periodic removal and installation of filters.
 - 7) Access Sections Immediately Upstream and Downstream of Filter Sections: **[Doors][Panels]**[, **with windows**].
 - 8) Mixing Section: **[Doors][Panels]**[, **with windows**].
 - 9) Humidifier Section: **[Doors][Panels]**[, **with windows**].
- e. Service Lights: **<Insert number of watts>[LED]<Insert lamp type>** vaporproof luminaire with individual switched junction box located **[outside][inside]**, adjacent to each access door and panel.
 - 1) Locations: **[Each section accessed with a door or panel][Fan section]<Insert location>**.

- f. Convenience Outlets: One 20-A duplex GFCI receptacle per location with junction box located on outside casing wall.
 - 1) Locations: **[Each section accessed with a door or panel][Fan section]<Insert location>**.
12. Condensate Drain Pans:
 - a. Location: Each type of **[cooling coil][heat wheel]**.
 - b. Construction:
 - 1) Single-wall, **[galvanized-steel or noncorrosive polymer][stainless steel]** sheet.
 - 2) Double-wall, **[galvanized-steel or noncorrosive polymer][stainless steel]** sheet with space between walls filled with foam insulation and moisture-tight seal.
 - c. Drain Connection:
 - 1) Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **[one end][both ends]** of pan.
 - 2) Minimum Connection Size: **[NPS 1 (DN 25)][NPS 2 (DN 50)]<Insert pipe size>**.
 - d. Slope: Minimum **[0.125-in./ft. (10-mm/mm)]<Insert value>** slope, **to comply with ASHRAE 62.1,** in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
 - e. Length: Extend drain pan downstream from leaving face **[for distance to comply with ASHRAE 62.1]<Insert distance>**.
 - f. Width: Entire width of water producing device.
 - g. Depth: A minimum of **[2 inches (50 mm)]<Insert dimension>** deep.
 - h. **[Formed sections][Integral part of floor plating]**.
 - i. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
 - j. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
- E. Fan, Drive, and Motor Section:
 1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
 2. Fans: Centrifugal, galvanized steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway.
 - b. Shaft Bearings:
 - 1) Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an **[L-50]<Insert bearing life rating>** rated life of **[200,000]<Insert number>** hours according to ABMA 9.
 - 2) Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and two-piece, cast-iron housing **[with grease lines extended to outside unit]** and an **[L-50]<Insert bearing life rating>** rated life of **[200,000]<Insert number>** hours according to ABMA 11.
 - 3) Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing **[with grease lines extended**

to outside unit] and an [L-50]<Insert bearing life rating> rated life of [200,000]<Insert number>.

- c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - 1) Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
- d. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
- e. Plenum Fan Arrays: **[Contained][Uncontained]** as defined in AHRI 430. Steel or aluminum frame with inlet cone and structural framing around each fan built into an array of multiple fans. Provide **[backdraft][motorized]** dampers at each fan to prevent short circuiting of flow if one fan is not operating.
- f. Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; **[steel][aluminum]** hub riveted to backplate and fastened to shaft with setscrews.
- g. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; **[steel][aluminum]** hub swaged to backplate and fastened to shaft with setscrews.
- h. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
- i. Mounting: For internal vibration isolation[**and seismic control**]. Factory-mount fans with manufacturer's standard[**restrained**] vibration isolation mounting devices having a minimum static deflection of [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.
- j. Shaft Lubrication Lines: Extended to a location outside the casing.
- k. Flexible Connector: Factory fabricated with a fabric strip minimum [3-1/2 inches (89 mm)][5-3/4 inches (146 mm)]<Insert dimension> wide, attached to two strips of minimum [2-3/4-inch- (70-mm-) wide]<Insert dimension> by [0.028-inch- (0.7-mm-) thick, galvanized-steel sheet][0.032-inch- (0.8-mm-) thick, aluminum sheets].
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
 - a) Fabric Minimum Weight: **26 oz./sq. yd. (880 g/sq. m).**
 - b) Fabric Minimum Tensile Strength: **480 lbf/inch (84 N/mm)** in the warp and **360 lbf/inch (63 N/mm)** in the filling.
 - c) Fabric Minimum Service Temperature Range: **Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).**
3. Drive, Direct: Factory-mounted, direct drive.
4. Drive, Belt: Factory-mounted, V-belt drive, with adjustable alignment and belt tensioning, and with [1.5][1.25] service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; [0.146-inch- (2.7-mm-)]<Insert dimension> thick, [3/4-inch (20-mm)]<Insert dimension> diamond-mesh wire screen, welded to steel angle frame; prime coated.

5. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 - d. Enclosure Materials: **[Cast iron]<Insert material>**.
 - e. Motor Bearings: **<Insert requirements>**.
 - f. Unusual Service Conditions:
 - 1) Ambient Temperature: **<Insert deg C>**.
 - 2) Altitude: **<Insert feet (m)>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
 - g. Efficiency: Premium efficient as defined in NEMA MG 1.
 - h. NEMA Design: **<Insert designation>**.
 - i. Motor Pulleys: Adjustable pitch for use with **[5]<Insert number>**-hp motors and smaller; fixed pitch for use with motors larger than **[5]<Insert number>** hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - j. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - k. **<Insert unique motor characteristics>**.
 - l. Mount unit-mounted disconnect switches on **[exterior][interior]** of unit.
6. Comply with Section 262923 "Variable-Frequency Motor Controllers."
7. Variable-Frequency Motor Controller: Serving **[each fan individually][all fans combined]** in fan array.
 - a. Manufactured Units: Pulse-width modulated; **[constant torque][and][variable torque]<Insert application>** for **[Design A and Design B][inverter-duty]** motors.
 - b. Output Rating: Three phase; 10 to **[60 Hz, with voltage proportional to frequency throughout voltage range][66 Hz, with torque constant as speed changes]**; maximum voltage equals input voltage.
 - c. Unit Operating Requirements:
 - 1) Internal Adjustability:
 - a) Minimum Speed: 5 to 25 percent of maximum rpm.
 - b) Maximum Speed: 80 to 100 percent of maximum rpm.
 - c) Acceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - d) Deceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - e) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - 2) Self-Protection and Reliability Features:
 - a) Surge suppression.
 - b) Loss of input signal protection.
 - c) Under- and overvoltage trips.
 - d) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - e) Critical frequency rejection.
 - f) Loss-of-phase protection.
 - g) Reverse-phase protection.

- h) Motor-overtemperature fault.
 - 3) Bidirectional autospeed search.
 - 4) Torque boost.
 - 5) Motor temperature compensation at slow speeds.
 - a) Panel-mounted operator station.
 - b) Historical logging information and displays.
 - c) Digital indicating devices.
 - 6) Control Signal Interface: Electric.
 - 7) Proportional Integral Directive (PID) control interface.
 - 8) DDC system for HVAC Protocols for Network Communications: **[ASHRAE 135]<Insert protocol type>**.
 - d. Line Conditioning:
 - 1) Input line conditioning.
 - 2) Output filtering.
 - 3) EMI/RFI filtering.
 - e. Bypass Systems:
 - 1) Bypass Mode: **[Manual operation only][Field-selectable automatic or manual]**.
 - 2) Bypass Controller, Two-Contactor Style: With bypass and output isolating contactors[**and isolating switch**].
 - 3) Bypass Controller, Three-Contactor Style: With bypass and input and output isolating contactors[**and isolating switch**].
 - 4) Bypass Contactor Configuration: **[Full-voltage (across the line)][Reduced-voltage (autotransformer)]<Insert type>** type.
- F. Coil Section:
- 1. General Requirements for Coil Section:
 - a. Comply with AHRI 410.
 - b. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
 - c. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
 - d. Coils shall not act as structural component of unit.
 - 2. Preheat Coils:
 - a. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
 - 1) Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
 - 2) Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - 3) Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 - 4) Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

- 5) Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - a) **[Magnetic][Mercury]** contactor.
 - b) Solid-state, stepless pulse controller.
 - c) Toggle switches, one per step.
 - d) Step controller.
 - e) Time-delay relay.
 - f) Pilot lights, one per step.
 - g) Airflow proving switch.
- b. Hot-Water Coils: **[Continuous circuit][Self-draining][Cleanable]**.
 - 1) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 2) Tube Material: **[Copper]<Insert material>**.
 - 3) Fin Type: Plate.
 - 4) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 5) Fin Spacing: Maximum **[10][12]<Insert spacing>** fins per inch (mm).
 - 6) Fin Thickness: **<Insert value> inches (mm)**.
 - 7) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 8) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 9) Frames: Channel frame, **[0.052-inch- (1.3-mm-) thick, galvanized steel][0.064-inch- (1.6-mm-) thick, galvanized steel][0.079-inch- (2.0-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, stainless steel]<Insert thickness><Insert material>**.
 - 10) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
 - 11) Coating: **[None][Corrosion-resistant coating]**.
 - 12) Integral Face-and-Bypass Dampers: **[Horizontal][Vertical]**, opposed-blade, **[galvanized-steel][aluminum][extruded-aluminum]** dampers with **[zinc-plated]** steel operating rods rotating in sintered bronze or nylon bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]** frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.
- c. Steam Coils: **[Distributed][Single tube]**.
 - 1) Steam Outer-Tube Diameter: **<Insert value> inches (mm)**.
 - 2) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 3) Tube Material: **[Copper]<Insert material>**.
 - 4) Fin Type: Plate.
 - 5) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 6) Fin Spacing: Maximum **[8][10][12]<Insert spacing>** fins per inch (mm).
 - 7) Fin Thickness: **<Insert value> inches (mm)**.
 - 8) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 9) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.

- b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 10) Frames: Channel frame, **[0.052-inch- (1.3-mm-) thick, galvanized steel][0.064-inch- (1.6-mm-) thick, galvanized steel][0.079-inch- (2.0-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, stainless steel]<Insert thickness><Insert material>**.
 - 11) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
 - 12) Coating: **[None][Corrosion-resistant coating]**.
 - 13) Integral Face-and-Bypass Dampers: **[Horizontal][Vertical]**, opposed-blade, **[galvanized-steel][aluminum][extruded-aluminum]** dampers with **[zinc-plated]** steel operating rods rotating in sintered bronze or nylon bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]** frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.
3. Heating Coils:
- a. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
 - 1) Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
 - 2) Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - 3) Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 - 4) Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 - 5) Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - a) **[Magnetic][Mercury]** contactor.
 - b) Solid-state, stepless pulse controller.
 - c) Toggle switches, one per step.
 - d) Step controller.
 - e) Time-delay relay.
 - f) Pilot lights, one per step.
 - g) Airflow proving switch.
 - b. Hot-Water Coils: **[Continuous circuit][Self-draining][Cleaning]**.
 - 1) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 2) Tube Material: **[Copper]<Insert material>**.
 - 3) Fin Type: Plate.
 - 4) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 5) Fin Spacing: Maximum **[10][12]<Insert spacing>** fins per inch (mm).
 - 6) Fin Thickness: **<Insert value> inches (mm)**.
 - 7) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 8) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to**

exterior of unit].

- b) Seamless copper tube with brazed joints, prime coated.
- c) Fabricated steel, with brazed joints, prime coated.
- d) Provide insulated cover to conceal exposed outside casings of headers.

- 9) Frames: Channel frame, **[0.052-inch- (1.3-mm-) thick, galvanized steel][0.064-inch- (1.6-mm-) thick, galvanized steel][0.079-inch- (2.0-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, stainless steel]<Insert thickness><Insert material>.**
- 10) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>.**
- 11) Coating: **[None][Corrosion-resistant coating].**

c. Steam Coils: **[Distributed][Single tube].**

- 1) Steam Outer-Tube Diameter: **<Insert value> inches (mm).**
- 2) Piping Connections: **[Threaded][Flanged], [same end][opposite ends]** of coil.
- 3) Tube Material: **[Copper]<Insert material>.**
- 4) Fin Type: Plate.
- 5) Fin Material: **[Aluminum][Copper]<Insert material>.**
- 6) Fin Spacing: Maximum **[10][12]<Insert spacing> fins per inch (mm).**
- 7) Fin Thickness: **<Insert value> inches (mm).**
- 8) Fin and Tube Joint: **[Mechanical bond][Silver brazed].**
- 9) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit].**
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
- 10) Frames: Channel frame, **[0.052-inch- (1.3-mm-) thick, galvanized steel][0.064-inch- (1.6-mm-) thick, galvanized steel][0.079-inch- (2.0-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, stainless steel]<Insert thickness><Insert material>.**
- 11) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>.**
- 12) Coating: **[None][Corrosion-resistant coating].**

4. Cooling Coils:

a. Chilled-Water Coil: **[Continuous circuit][Self-draining][Cleanable].**

- 1) Piping Connections: **[Threaded][Flanged], [same end][opposite ends]** of coil.
- 2) Tube Material: **[Copper]<Insert material>.**
- 3) Tube Thickness: **<Insert value> inches (mm).**
- 4) Fin Type: Plate.
- 5) Fin Material: **[Aluminum][Copper]<Insert material>.**
- 6) Fin Spacing: **[0.125 inch (3.18 mm)][0.091 inch (2.31 mm)][0.071 inch (1.80 mm)][0.067 inch (1.70 mm)][0.056 inch (1.42 mm)][0.0075 inch (0.19 mm)]<Insert fins per inch (mm)>.**
- 7) Fin Thickness: **<Insert value> inches (mm).**
- 8) Fin and Tube Joint: **[Mechanical bond][Silver brazed].**
- 9) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to**

- G. Air Filtration Section:

- ## San Bernardino County, Specifications

- a. Description: Factory-fabricated, **[adhesive-coated]**disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pleats are maintained in pleated form under rater-airflow conditions by corrugated aluminum separators.
 - d. Filter Media Frame: **[Galvanized steel]<Insert material>**.
7. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
 8. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 9. Front- or Back-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: **[Galvanized-steel][Aluminum]** framing members with **[front][back]** access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
 - 1) Prefilters: Incorporate a separate **[2-inch- (50-mm-)]<Insert dimension>** thick track**[with spring clips]**, with same access as primary filter.
 - 2) Sealing: Full periphery foam gaskets.
 - b. HEPA Filter Frames: **[Aluminum][Stainless steel]** framing members, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation operation. Bolted filter-sealing mechanism shall mount and continuously seal each individual filter.
 - 1) Prefilters: Incorporate a separate **[2-inch- (50-mm-)][4-inch- (50-mm-)]<Insert dimension>** thick track**[with spring clips]** with same access as primary filter.
 - 2) Sealing: **[Gasketed][or][gel]**, hand-crank locking mechanism to provide positive-sealing for each filter to ensure seal between filter elements to prevent bypass of unfiltered air.
 - c. Gas-Phase Air Filter Frames: **[Galvanized-steel][Aluminum]** framing members with access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
 - 1) Prefilters: Incorporate a separate **[2-inch- (50-mm-)]<Insert dimension>** thick track**[with spring clips]**.
 - 2) Sealing: **[Full periphery foam gaskets][Positive-sealing-device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air]**.
 10. Side-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. **[Galvanized steel][Aluminum]** track.
 - 1) Prefilters: Incorporate an integral **[2-inch- (50-mm-)]<Insert dimension>** thick track with same access as primary filter.
 - 2) Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent

bypass of unfiltered air.

b. HEPA Filter Frames:

- 1) Frames: Match inner casing and outer casing material, and insulation thickness. **[Aluminum][Stainless steel]** track.
- 2) Prefilters: Incorporate an integral **[2-inch- (50-mm-)][4-inch- (100-mm-)]<Insert dimension>** thick track,
- 3) Sealing: Incorporate positive-sealing clamping device on each filter between **[gasket][gel]** seal on all sides of filter cartridge frames to prevent bypass of unfiltered air.

c. Gas-Phase Air Filter Frames:

- 1) Frames: Matching inner casing and outer casing material, and insulation thickness. **[Galvanized-steel][Aluminum]** track.
- 2) Prefilters: Incorporate an integral **[2-inch- (50-mm-)]<Insert dimension>** thick track.
- 3) Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

H. Dampers:

1. Comply with requirements in Section 230923.12 "Control Dampers."
2. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, **[galvanized-steel][aluminum][extruded-aluminum]<Insert material>** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **[opposed][parallel]-**blade arrangement with **[zinc-replated]** steel operating rods rotating in **[stainless steel sleeve][sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]<Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed **[4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa), leakage Class 1]<Insert requirement>**, **tested, rated, and labeled in accordance with AMCA 511**.
3. Face-and-Bypass Dampers: Opposed-blade, **[galvanized-steel][aluminum][extruded-aluminum]** dampers with **[zinc-plated]** steel operating rods rotating in sintered bronze or nylon bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]** frame and with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
4. Zone Dampers: Two single-blade, **[galvanized-steel][aluminum][extruded-aluminum]<Insert materials>** dampers offset 90 degrees from each other on **[zinc-plated]** steel operating rod rotating in sintered bronze or nylon bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]<Insert material>** frame. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
5. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
6. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - c. Operator Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

- 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
- d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
- e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
- f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft. (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
- g. Coupling: V-bolt and V-shaped, toothed cradle.
- h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
- i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
- j. Power Requirements (Two-Position Spring Return): **[24 V dc][120 V ac][230 V ac]**.
- k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
- l. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
- m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.
- n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.
7. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.
8. Combination Filter and Mixing Section:
 - a. Cabinet support members shall hold **[2-inch- (50-mm-)]<Insert dimension>** thick, pleated, flat, permanent or throwaway filters.
 - b. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.
- I. Sound Attenuators:
 1. General Requirements:
 - a. Factory fabricated.
 - b. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50; ASTM E84.
 - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with ASHRAE 62.1.

2. Shape: **[Rectangular, straight][Round, straight][Rectangular, elbow][Round, elbow]**.
3. Rectangular Silencer Outer Casing: **[Galvanized steel]<Insert material>**.
4. Round Silencer Outer Casing: **[Galvanized steel]<Insert material>**.
5. Inner Casing and Baffles: **[Galvanized steel]<Insert material>**.
6. Principal Sound-Absorbing Mechanism:
 - a. Packless Type: Controlled impedance membranes and broadly tuned resonators without adsorptive media.
 - b. Dissipative Type: **[Polymer film-lined]**absorptive fill material.
 - 1) Fill Material: **[Inert and vermin-proof fibrous material]<Insert material type>**.
 - c. Joints: Lock formed and sealed, continuously welded or flanged.

J. Humidifiers:

1. Direct-steam-injection humidifiers are specified in Section 238413.23 "Direct-Steam-Injection Humidifiers."
2. Self-contained humidifiers are specified in Section 238413.29 "Self-Contained Humidifiers."
3. Heat-exchanger humidifiers are specified in Section 238413.36 "Heat Exchanger Humidifiers."

K. Air-to-Air Energy Recovery Units:

1. Heat Wheels:
 - a. Casing:
 - 1) Galvanized steel, stainless steel, or aluminum with manufacturer's standard factory finish.
 - 2) Integral purge section limiting carryover of exhaust air to between **[0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.5 percent at 400-Pa and 0.20 percent at 1000-Pa)]<Insert values>** differential pressure.
 - 3) Casing seals on periphery of rotor, on duct divider, and on purge section.
 - 4) Support vertical rotors on grease-lubricated ball bearings with extended grease fittings. Mount horizontal rotors on tapered roller bearing.
 - b. Rotor, Aluminum or Polymer: Segmented wheel, strengthened with radial spokes[, **with nontoxic, noncorrosive, silica-gel desiccant coating**].
 - c. Rotor - Aluminum, Metallic, or Polymer: Segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating.
 - d. Drive: Fractional horsepower motor and gear reducer[, **with speed changed by variable-frequency controller**]. Permanently lubricated wheel bearings with an **[L-10]<Insert bearing life>[400,000 hours]<Insert hours>**.
 - e. Controls:
 - 1) Starting relay, factory mounted and wired, and manual motor starter for field wiring.
 - 2) Variable-frequency controller, factory mounted and wired, permitting input of field connected 4- to 20-mA or 1- to 10-V control signal.
 - 3) Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
 - 4) Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain **[exhaust temperature above freezing and]**air differential temperature above set point. Provide maximum rotor speed when

- exhaust-air temperature is less than outdoor-air temperature.
 - 5) Pilot-Light Indicator: Display rotor rotation and speed.
 - 6) Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
 2. Fixed-Plate Sensible Heat Exchangers:
 - a. Casing: **[Aluminum][Galvanized steel]<Insert material>**.
 - b. Plates: Evenly spaced and sealed and arranged for **[counter][cross]** airflow.
 - c. Plate Material: **[Embossed aluminum][Stainless steel][High-density plastic]**.
 - d. Plate Coating: **[Epoxy]<Insert coating>**.
 - e. Bypass: Plenum within casing, with gasketed face-and-bypass dampers that have operating rods extended outside casing.
 - f. Heat-Exchanger Prefilters:
 - 1) Thickness: **[1 inch (25 mm) thick, disposable][2 inches (50 mm) thick, disposable]<Insert type>**.
 - 2) MERV Rating: **[MERV 6]<Insert MERV rating>**.
- L. Air Blenders:
 1. Description: Static air mixer device to provide mixing of two airstreams to within **[plus/minus 6 deg F (3 deg C)]<Insert mixing differential>**.
 2. Material: **[Galvanized steel][Aluminum]<Insert material>**.
 3. Coating: **[None][Corrosion-resistant coating]**.
- M. Diffusers:
 1. Description: Velocity profile equalizer device for providing equalized airflow profile downstream of Type DWDI fans.
 2. Material: **[Galvanized steel][Aluminum]<Insert material>**.
- N. UV-C Lamp Systems:
 1. Description:
 - a. UV-C lamp system consisting of power supply, power supply housing, wiring, UV lamp(s), lamp plug, lamp plug protector, encapsulated lamp, and lamp holder used for UV germicidal irradiation of cooling coil and condensate drain pan.
 - b. Factory installed and preengineered.
 2. Standard: UL Category Code ABQK, HVAC accessories, air-duct mounted.
 3. Lamps: High output, hot cathode.
 4. Lamp-Holder Construction:
 - a. UV- and moisture-resistant materials and designed to connect the lamp to the plug.
 - b. Adjustable positioning.
 5. Lamp-Clamp Construction:
 - a. UV- and moisture-resistant materials, water-tight connection.
 - b. Adjustable positioning.
 6. Lamp Protection: Hermetically sealed to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.
 7. Lamp Output: UV-C energy, primarily at the 254-nm wavelength with a 360-degree energy distribution.

8. Access Door Interlocks: Automatic disconnect on all access doors into UV-installed casing sections to shield servicing personnel from contact with light.
9. Power Supply: UL-listed, single-point electrical connection[**with service disconnect**].
10. Power Consumption: Maximum of [**15 W/sq. ft. (161 W/sq. m)**]<Insert value>.

O. Roof Curbs:

1. Roof curbs with vibration isolators [**and**][**wind**][**or**][**seismic**] restraints are specified in [**Section 230548 "Vibration and Seismic Controls for HVAC."**][**Section 230548.13 "Vibration Controls for HVAC."**]
2. Materials: Galvanized steel with corrosion-resistant coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 - a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1) Materials: ASTM C1071, Type I or II.
 - 2) Thickness: [**1 inch (25 mm)**][**1-1/2 inches (38 mm)**][**2 inches (50 mm)**]<Insert dimension>.
 - b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C916, Type I.
 - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - 3) Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
3. Curb Dimensions: Height of [**14 inches (355 mm)**][**24 inches (610 mm)**][**36 inches (910 mm)**]<Insert dimension>.[**Adaptable horizontal dimensions as required for existing roof openings.**]
4. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in [**Section 230548 "Vibration and Seismic Controls for HVAC"**][**Section 230548.13 "Vibration Controls for HVAC"**] for wind-load requirements.

P. Intake and Relief Air Openings:

1. Provide hood, including moisture eliminator, over all unit intake and relief openings. Match material and finish of casing exterior.

2.4 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or

moisture.

- C. Galvanized Steel: ASTM A653/A653M.
- D. Aluminum: **ASTM B209 (ASTM B209M)**.
- E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
- F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a **[3000]<Insert time>**-hour salt-spray test according to ASTM B117.
 - 1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
 - c. ASTM B3359 for cross-hatch adhesion of 5B.
 - 2. Application: **[Immersion][Spray]**.
 - 3. Thickness: **[1 mil (0.025 mm)]<Insert value>**.
 - 4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.5 SOURCE QUALITY CONTROL

- A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.
- B. AHRI 1060 Certification: Test, rate, and label air-handling units that include air-to-air energy recovery devices in accordance with AHRI 1060.
- C. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.
- D. Fan Aerodynamic Performance Rating: Test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210.
- E. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- F. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- G. Water Coils: Factory tested to **300 psig (2070 kPa)** according to AHRI 410 and ASHRAE 33.
- H. Steam Coils: Factory tested to **300 and 200 psig (2070 and 1380 kPa)** underwater according to AHRI 410 and ASHRAE 33.
- I. Refrigerant Coils: Factory tested to minimum **450-psig (3105-kPa)** internal pressure and to minimum **300-psig (2070-kPa)** internal pressure while underwater, according to AHRI 410 and ASHRAE 33.
- J. Witnessed Casing Leakage Tests:
 - 1. Pay for all expenses, for one representative designated by Owner, to travel to the factory to witness cabinet air-leakage testing on the specific assembled unit(s) prior to release for delivery to Project site.
 - 2. If the unit(s) does not meet specified leakage requirements, perform factory modifications and

retest. Do not release unit for shipment until tested leakage is measured to be within specified leakage and leakage testing report has been accepted by Owner's designated representative.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

- A. Roof Curb: Install on roof structure or concrete base, level and secure, according to **[NRCA's "NRCA Roofing Manual: Membrane Roof Systems."][AHRI Guideline B.]** Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
- B. Unit Support: Install unit level on structural **[curbs][steel supports]**. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of **[curbs][steel supports]** with actual equipment provided.
 - 1. Comply with requirements for vibration isolation[, **wind-control**][and][**seismic-control**] devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 2. Comply with requirements for vibration isolation **[and][wind-control]** devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
- E. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, allow space for service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using **[NPS 1-1/4 (DN 32)]<Insert pipe size>, ASTM B88, Type M (ASTM B88M, Type C)** copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- F. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.
- G. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that face-and-bypass dampers provide full face flow.
8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
9. Comb coil fins for parallel orientation.
10. Verify that proper thermal-overload protection is installed for electric coils.
11. Install new, clean filters.
12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. **[Replace fan and motor pulleys as required to achieve design conditions.]**
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.7 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.8 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner][Contractor]** will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
 2. Charge refrigerant coils with refrigerant and test for leaks.
 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 4. HEPA Filters: Pressurize housing to a minimum of **3-inch wg (750 Pa)** or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
 5. HEPA Filters, Critical Applications: Pressurize housing to a minimum of **3-inch wg (750 Pa)** or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter for air leaks according to ASME AG-1, pressure-decay method.
 6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 7. Air-handling unit and components will be considered defective if unit or components do not pass tests and inspections.
 8. Prepare test and inspection reports.

3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 74 00 00



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 74 00 00A - OUTDOOR, CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Outdoor, custom air-handling units.

B. Related Requirements:

1. Section 237313.19 "Indoor, Custom Air-Handling Units."

1.2 ACTION SUBMITTALS

A. Product Data: For each outdoor, custom air-handling unit.

1. Product information organized to show compliance with each performance requirement of "Performance Requirements" article.
2. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
3. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
4. Include unit dimensions and weight.
5. Include cabinet material, metal thickness, finishes, insulation, and accessories.
6. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated. For fans operating at variable speeds include curves in [10]<Insert number> percent speed increments starting at design speed down to minimum speed.
 - b. Include fan-sound power ratings in all eight octave bands. Include inlet or outlet sound power levels to coincide with sound requirements indicated on Drawings.
 - c. Include fan construction and accessories. Submit sufficient information to show product compliance with requirements indicated.
 - d. Include dimensions and weight.
 - e. Include motor ratings, electrical characteristics, and motor accessories.
7. Vibration isolation product data with performance ratings. Uniquely identify and include information for each different isolator type and indicate for each air-handling unit where each isolator type is being used.
8. Include certified coil-performance ratings with system operating conditions indicated. Product data to include: dimensions, dry and operating weight, volume of fluid contained, materials of construction, and performance ratings with system operating conditions indicated.
9. Casing insulation product data and performance ratings.
10. Access door and access panel product data and performance ratings.
11. Roofing product data and performance ratings.
12. Louver product data and performance ratings.
13. Paint product data and performance ratings.
14. Electrical product data and performance ratings.
15. Metal grating product data and performance ratings.
16. Electric heater product data with performance ratings.



17. Steam humidifier product data with performance ratings.
18. Dampers product data, including housings, linkages, and operators with performance ratings.
19. Filters product data with performance characteristics.
20. Heat wheels product data with performance ratings.
21. Fixed plate heat exchangers product data with performance ratings.
22. Heat pipe heat exchangers product data with performance ratings.
23. Duct silencers product data with performance ratings.
24. Air blender product data with dimensions, weights, materials of construction, performance ratings, and installation requirements.
25. UV-C lamp systems product data with performance ratings.
26. Pumps product data with performance ratings.
27. Hydronic pipe, valves, fittings, vents, strainers, and hydronic accessories product data.
28. Steam and condensate pipe, valves, fittings, vents, strainers, and steam specialties product data.
29. Pipe insulation and jacket product data.
30. Roof curbs product data.
31. **<Insert requirements>.**

B. Sustainable Design Submittals:

1. Product Data: Showing compliance with ASHRAE 62.1.
2. Product data indicating compliance with ASHRAE/IES 90.1.
3. Product Data: For air filtration performance.
4. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
5. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each type and configuration of indoor, custom air-handling unit.

1. Prepared by manufacturer's factory employees with review and sign-off by those individuals responsible for manufacturing the air-handling units.
2. Include plans, elevations, sections, and **[mounting][attachment]** details. **[For air-handling units consisting of multiple levels, create drawings for each level showing interrelationship of levels superimposed.]**
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, methods of field assembly, components, and location and size of each field connection.
4. Detail fabrication and assembly of indoor, custom air-handling units, as well as procedures and diagrams.
5. Indicate details of construction with materials description including applicable specified standards and material grades in sufficient detail for reviewers to evaluate point by point compliance with requirements indicated for each air-handling unit.
6. Use actual dimensions of internal equipment in preparing Shop Drawings. Identify mechanical equipment shown on Shop Drawings with equipment designations on Drawings.
7. Thickness and finish of all casing materials with cross references indicated where each is used. Uniquely identify and include information for each different casing construction.
8. Details for each unique casing joint and reinforcing. Indicate wall joints, wall to floor joints, wall to roof joints, floor joints, and roof joints.
9. Roofing details.
10. Assembly details of base and casing for units consisting of multiple sections requiring field assembly.
11. Sizes and dimensioned locations of field connections for ductwork, piping, electrical, and controls.
12. Base and casing penetration and sealing details for factory-installed conduit.
13. Base and casing penetration and sealing details for factory-installed piping including coils **[and steam humidifiers]**.
14. Details of casing connections to field-installed ductwork.

15. Size, shape and layout of base members including localized support of internal components.
16. Base materials, thickness, finishes, lifting provisions, and mounting requirements. Uniquely identify and include information for each different base construction. Clearly indicate for each air-handling unit.
17. Recommended points of field attachment with dimensioned locations.
18. Size and location of each access door, including clearing opening size, with door swing indicated.
19. Size and location of each access panel with service equipment superimposed to show relationship of panel to internal equipment.
20. Drain pans and associated piping, with sizes and locations dimensioned, including relationship to internal equipment.
21. Floor drains and associated piping, with sizes and locations dimensioned, including relation to internal equipment.
22. Coil framework and support including enlarged details showing framework attachment to air-handling unit base, coil attachment to framework, and means for individual coil removal.
23. Mounting details of all internal components, such as fans, filters, and dampers.
24. Hoist rails layout for internal equipment showing size of members, attachments to structure, and serviced equipment superimposed to indicate relationships.
25. Size and location of catwalks, handrails, ladders, and safety cages including construction details and details of attachment to air-handling unit base.
26. Location of UV-C lamp systems, service clearances, and mounting details.
27. Location of receptacles, service lights, and switches.
28. Location of motor controllers and disconnect switches.
29. Size and location of junction boxes used for interface with field electrical power.
30. Point-to-point electrical power wiring diagrams including wire size, conduit size, motor controllers sizes, switch types and ratings, receptacle types and ratings, service light fixture types and ratings.
31. Point-to-point control wiring diagrams including cable types and sizes, conduit sizes, and connected control devices.
32. Point-to-point control tubing diagrams including tubing types and sizes, conduit sizes, and connection controls devices.
33. Control panel drawings drawn to scale showing detailed internal layout.
34. Plans, sections and isometric reviews of **[hydronic][and][steam and condensate]** piping systems showing pipe, fittings, flanges, unions, valves, vents, strainers, accessories, specialties and insulation.
35. Indicate code, operating, and maintenance clearances drawn to scale using dashed lines.
36. Indicate weights of internal components, weight of each separately shipped section, and air-handling unit total weight.
37. **<Insert requirements>**.

D. Comparison Schedule:

1. Submit a schedule to indicate performance of equipment scheduled on Drawings directly compared to performance of submitted equipment.
2. Clearly identify each line in schedule to indicate "Scheduled" where indicating performance scheduled on Drawings and "Submitted" where indicating performance of submitted equipment.
3. Organize schedule to first indicate performance scheduled on Drawings on one line followed by line directly below that indicates performance of submitted equipment.
4. Comparison schedule shall follow arrangement and organization of scheduled information indicated on Drawings.
5. Submitted equipment shall have a value for each scheduled value indicated.

E. Delegated Design Submittals: For vibration isolation[**and seismic restraints**] indicated to comply with performance requirements and design criteria, including analysis data[**signed and sealed by the professional engineer responsible for their preparation**].

1. For seismic restraints indicated to comply with performance requirements and design criteria,

including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

- a. Include design calculations for selecting seismic restraints.

2. <Insert requirements>.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.
- B. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Restraint of internal components.
- C. Source quality-control reports.
- D. Startup service reports.
- E. Field quality-control reports.
- F. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Bag Filters: [One]<Insert number> set(s) for each air-handling unit.
 2. Cartridge Filters: [One]<Insert number> set(s) for each air-handling unit.
 3. Panel Filters: [One]<Insert number> set(s) for each air-handling unit.
 4. Absolute Filters: [One]<Insert number> set(s) for each air-handling unit.
 5. Gas-Phase Filters: [One]<Insert number> set(s) for each air-handling unit.
 6. Access Door Gaskets: [One]<Insert number> set(s) for each [unique]access door.
 7. Fan Belts: [One]<Insert number> set(s) for each fan with belt-drive assembly.
 8. Heat Wheel Belts: [One]<Insert number> set(s) for each heat wheel with belt-drive assembly.
- B. Tool Kit: Manufacturer to provide a tool kit including special tools required for air-handling unit service.

See "Accessories" Article for additional requirements.

1.6 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.7 FACTORY VISITS FOR PRODUCT INSPECTION

- A. While units are being manufactured, and during factory normal working hours, allow escorted access to manufacturing facility for [Owner][or][and][Owner's designated representative] to verify product compliance with requirements indicated.
 - 1. As many as <Insert number> persons shall visit the factory for product inspection.
- B. Manufacturer shall provide [Owner][and][Architect] with written notice at least [30]<Insert number> business days before units go into assembly.
- C. Inspection visits shall be scheduled with manufacturer at least [10]<Insert number> business days before visit.
- D. Personnel making visits for purposes of product inspection shall comply with manufacturer requirements for visitors.

1.8 DELIVERY, STORAGE, HANDLING

- A. Deliver air-handling units with factory-installed shipping skids and lifting lugs; pack small components in factory-fabricated protective containers. Cover units with heat-shrinkable plastic sheeting suitable for shipping from point of manufacture to Project.
- B. Handle air-handling units carefully to avoid damage to components, casing, and finish. Do not install damaged components; replace and return damaged components to air-handling unit manufacturer.
- C. Store air-handling units in a clean dry place and protect them from weather and construction activities.
- D. Keep air-handling units fully covered and protected during construction. Remove dirt and debris and clean units to a factory-cleaned condition.
- E. Comply with manufacturer's written rigging and installation instructions for unloading air-handling units and moving them to their final locations.
- F. For air-handling units equipped with key locks on access doors, keep doors locked during construction.
 - 1. If access is required within air-handling units, only open the doors to sections that require access and lock doors at the end of each [workday][work shift]<Insert requirement>.
 - 2. Protect inside of air-handling units from damage and keep inside of units as clean as the factory-cleaned condition.
 - 3. Report observed abuse to <Insert entity> for immediate corrective action.

1.9 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of air-handling units that fails in materials or workmanship within specified warranty period.
 - 1. Warranty Period: **<Insert number>** year(s) from date of Substantial Completion.
- B. Extended warranties include, but are not limited to, the following:
 - 1. Complete Air-Handling Unit: **[Two][Three][Five]<Insert number>** years from date of Substantial Completion for entire air-handling unit and longer where indicated for individual components.
 - 2. Air-Handling Unit Casing: **[25][30]<Insert number>** years from date of Substantial Completion.
 - 3. Air-Handling Unit Roofing: **[25][30]<Insert number>** years from date of Substantial Completion.
 - 4. Motors: **[Two][Five]<Insert number>** years from date of Substantial Completion
 - 5. Heat Wheels: **[Five][10]<Insert number>** years from date of Substantial Completion.
 - 6. **<Insert requirement>**.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional **[specialist][engineer]**, as defined in Section 014000 "Quality Requirements," to design air-handling units, **[vibration isolation,][and seismic restraints]** including comprehensive engineering analysis, using performance requirements and design criteria indicated.
- F. Casing Structural Performance:
 - 1. Floor: Capable of withstanding positive/negative **[8 inches wg (2000 Pa)]<Insert value>** of internal static pressure, without exceeding a deflection of **[L/300][L/360]<Insert deflection>** of span.
 - 2. Walls and Roof: Capable of withstanding positive/negative **[8 inches wg (2000 Pa)]<Insert value>** of internal static pressure, without exceeding a midpoint deflection of **[L/200][L/240]<Insert deflection>** of span.
- G. Casing Leakage Performance, ASHRAE 111: **[Class 3 leakage]<Insert leakage class>** or better at **[plus or minus 8 inches wg (2000 Pa)]<Insert pressure>**.
- H. Casing Leakage Performance: Comply with more stringent of the following requirements:

1. ASHRAE 111, [Class 3 leakage]<Insert leakage class> or better at [plus or minus 8 inches wg (2000 Pa)]<Insert pressure>.
 2. Not more than [0.5]<Insert number> percent of the total unit airflow at [8 inches wg (2000 Pa)]<Insert pressure>.
- I. Casing Thermal Performance:
1. Surface Condensation: Air-handling manufacturer shall evaluate potential for condensation and design and manufacture entire unit casing to prevent condensation at most extreme operating conditions encountered.
 2. Thermal Break: Incorporate a thermal break at each through metal path to prevent condensation from occurring on interior and exterior of casing.
 3. U-Value: Overall U-value or equivalent R-value of casing shall not exceed governing codes and ASHRAE/IES 90.1 while considering the effects of metal-to-metal contact and thermal bridging in calculations.
- J. Air Tunnel Aerodynamic Performance: Position air-handling unit internal components and transition between internal components to maintain uniform airflow; minimize sound levels and energy consumption. Use methods indicated and other means to ensure compliance.
1. Use turning vanes if necessary to direct the air path.
 - a. Design, manufacture, and install vanes in accordance with applicable requirements in ASHRAE and SMACNA guidelines, handbooks, and standards.
 - b. Install vanes firmly in place so that no vane movement occurs at worst-case airflow capacity possible.
 2. Use fan inlet and discharge transitions and other devices to maximize system regain and minimize airborne sound levels.
 3. Center system components such as coils, fans, and filters, vertically and horizontally, in the airstream.
 4. Maintain spacing between components such that airflow patterns to adjacent components are as uniform as possible and that component "dead spots" or "jetted areas" are avoided.
 5. Design and install internal structural supports, piping, and conduit that do not block airflow and impede performance of coils, fans, filters, and other unit components, and service space clearances.
- K. Air-Handling Unit Acoustical Performance:
1. Radiated Noise: Noise radiated from air-handling unit casing[and openings not ducted] shall not exceed following sound pressure levels when measured [3 feet (900 mm)]<Insert distance> away from any exterior surface of unit. Sound pressure levels indicated in each octave band are in decibels (dB) (reference 20 µPa).
 - a. 63 Hz: <Insert value> dB.
 - b. 125 Hz: <Insert value> dB.
 - c. 250 Hz: <Insert value> dB.
 - d. 500 Hz: <Insert value> dB.
 - e. 1000 Hz: <Insert value> dB.
 - f. 2000 Hz: <Insert value> dB.
 - g. 4000 Hz: <Insert value> dB.
- L. Casing Acoustical Performance:
1. Sound Absorption: Minimum acceptable sound absorption coefficient and noise reduction coefficient (NRC) of perforated inside casing assemblies when tested by an independent testing

laboratory in accordance with ASTM C423 and ASTM E795:

- a. 125 Hz: <Insert value> dB.
 - b. 250 Hz: <Insert value> dB.
 - c. 500 Hz: <Insert value> dB.
 - d. 1000 Hz: <Insert value> dB.
 - e. 2000 Hz: <Insert value> dB.
 - f. 4000 Hz: <Insert value> dB.
 - g. NRC: <Insert value>.
- M. Durability Performance: Design and manufacture air-handling units with underlying requirement to provide a highly durable piece of equipment.
1. Unit Life Expectancy: [25]<Insert number> years.
 2. Supporting Documentation: Submit documentation showing proposed products to consider and include design features, components, and materials to satisfy requirement.
- N. Extreme Operating Conditions:
1. Corrosive Environments: Air-handling unit manufacturer shall evaluate the quality and potential corrosiveness of air passing through air-handling units and propose additional protective finishes and better-quality materials of a heavier thickness if required to comply with requirements indicated.
 - a. Unless otherwise indicated, air-handling units for HVAC applications may use up to 100 percent of outdoor air or a mix of outdoor air with return air from habitable areas served. [**Projects located in coastal and industrial areas may require added protection.**]
 - b. Air-handling units circulating [Class 3][and][Class 4] exhaust air in accordance with ASHRAE 62.1 could potentially be hot, humid, and corrosive and may require added protection.
 2. Humidity and Temperatures: Materials and components of air-handling units shall be suitable for use in low and high humidity and temperature extremes when operating under normal and abnormal conditions without permanent degradation or loss in material performance.
- O. Outdoor Environment:
1. Air-handling units specially designed to withstand effects of wind, rain, ice, snow, seismic, air quality, sun, and other influences associated with outdoor installations.
 2. Comply with requirements of air-handling unit and governing codes.
- P. Safety:
1. Comply with OSHA regulations.
 2. Exposed sharp edges and corners of metal shall be protected or rounded to prevent injury to personnel not wearing gloves.
 3. Cover exposed ends of screws with plastic or metal covers to prevent injury to personnel coming in contact with screws.
- Q. Serviceability:
1. Hoisting Provisions: Fans and motors weighing more than [200 lb (91 kg)]<Insert weight> shall have full-length hoist rails mounted over the equipment to facilitate service, removal, and replacement.
 2. Mounting Location: Install internal components in readily accessible locations to facilitate ease of

- service and replacement.
 - 3. Service Access:
 - a. Internal components shall be serviceable through access sections with doors indicated on Drawings.
 - b. Internal components shall be removable and replaceable through access doors or panels.
 - c. Review requirements for access doors and panels indicated and recommend additional access doors and panels if required for uninhabited service, removal, and replacement of components.
 - 4. Tripping Hazards: Floors in accessible sections of air-handling unit shall be free of standing seams, reinforcing, supports, or section splits located in the walking path that is capable of causing a tripping hazard. Locate section splits immediately adjacent to internal walls.
 - R. Quality: Type and thickness of materials indicated are the minimum acceptable. Provide better-quality materials of a heavier thickness if required to comply with performance requirements indicated.
 - 1. If manufacturer's standard construction exceeds requirements indicated, use manufacturer's standard construction.
 - 2. If manufacturer's standard construction does not comply with requirements indicated, modify manufacturer's standard construction to comply with requirements.
 - S. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined in accordance with [ASCE/SEI 7]<Insert requirement>.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: [1.5][1.0].
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>.**
 - T. Vibration Performance: Air-handling unit manufacturer shall evaluate vibration of internal components installed inside of air-handling units and include internal vibration isolation required to limit the vibration transmitted to the building at a low enough level that vibration is not perceived by building occupants.
- 2.2 CAPACITIES AND CHARACTERISTICS
- A. See equipment schedules on Drawings.
- 2.3 SOURCE LIMITATIONS
- A. Source all outdoor [**and indoor**]custom air-handling units from same manufacturer.
 - B. Like components furnished with air-handling units shall be from same manufacturer.
 - C. Air-handling units shall be manufactured in [**United States**][**United States or Canada**][**North America**]<Insert requirement>.
 - D. **<Insert requirements>.**

2.4 OUTDOOR, CUSTOM AIR-HANDLING UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[Air Enterprises, LLC]**
2. **[Buffalo Air Handling]**
3. **[Climate Craft]**
4. **[Engineered Air]**
5. **[Environmental Air Systems]**
6. **[Haakon Industries]**
7. **[HUNTAIR; A Nortek Air Solutions Company]**
8. **[Temtrol; A Nortek Air Solutions Company]**
9. **[Trane; An Ingersoll Rand Company]**
10. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. **[Air Enterprises, LLC]**
2. **[Buffalo Air Handling]**
3. **[Climate Craft]**
4. **[Engineered Air]**
5. **[Environmental Air Systems]**
6. **[Haakon Industries]**
7. **[HUNTAIR; A Nortek Air Solutions Company]**
8. **[Temtrol; A Nortek Air Solutions Company]**
9. **[Trane; An Ingersoll Rand Company]**
10. **<Insert manufacturer's name>**

- C. Unit Arrangement and Configuration:

1. Arrangement: Project-specific arrangement and configuration of air-handling units indicated on Drawings. Do not deviate from requirements indicated **[without submitting a formal request clearly describing each deviation and reason for each deviation, and only after receiving Architect's written acceptance]**.
2. Mounting Requirements: **[Indicated on Drawings][Units mounted on concrete housekeeping pads][Units mounted on structural floor][Units mounted on structural-steel frame][Units suspended from structure][Units mounted on roof curbs]**.
3. Multiple Sections: Each air-handling unit shall consist of multiple sections for field assembly to comply with requirements indicated on Drawings.
4. Multiple Sections, Splits: Air-handling unit manufacturer to determine number of sections and location of section splits required for each air-handling unit in accordance with the following criteria:
 - a. Physical size and weight of each section, on-site path of travel, and methods for erection and installation. Air-handling manufacturer to review criteria with Installer before preparing Shop Drawings.
 - b. Maximize physical size of each air-handling unit section considering, shipping, moving, erecting, and installation.
 - c. Minimize the number of air-handling unit sections requiring field assembly. Preference is for single-piece air-handling units where possible.

- D. Air-Handling Unit Base:

1. Performance:
 - a. Air-handling unit manufacturer shall design and assemble air-handling unit casing and internal components for attachment and support by air-handling unit structural base.
 - b. Design air-handling units to be lifted from only the air-handling unit structural base and not the casing.
 - c. Support air-handling units from only the perimeter base unless otherwise indicated on Drawings.
 - d. Air-handling unit manufacturer to size and locate intermediate structural base supports as required to comply with structural performance indicated for air-handling unit floors.
 - e. Level base before factory assembly of air-handling unit casing and internal components to ensure proper fit and alignment.
2. Structural Member Size:
 - a. Air-handling unit manufacturer shall select size of base members and construction of base to withstand the rigors of loading, unloading, shipping, and rigging without damage to air-handling unit components or misalignment of factory-assembled components.
 - b. Depth and weight of structural members shall be selected by air-handling unit manufacturer to comply with performance requirements indicated.
 - c. Depth of perimeter base members is not less than **[size indicated on Drawings][1/10 of the unit width][8 inches (200 mm) deep]<Insert requirement>**.
3. Structural Member Spacing: Positioned as required to comply with requirements indicated, but not to exceed **[24 inches (600 mm)]<Insert requirement>**.
4. Materials: **[Structural aluminum, ASTM B209 (ASTM B209M), Alloy 6061 T6][Structural carbon steel, ASTM A36/A36M][Structural stainless steel, ASTM A276/A276M, Type 304L][or][structural stainless steel, ASTM A276/A276M, Type 316L][as indicated on Drawings]**.
 - a. Perimeter Members: **[Angle][channel][I or W beam shapes][or][tube]**.
 - b. Intermediate Members (Spanning Full Width of Unit): **[Angle][channel][or][I or W beam shapes][or][tube]**.
 - c. Cross Members (Spanning Intermediate Members): **[Angle][channel][or][tube]**.
5. Carbon Steel Finish, Mill Galvanized: Mill-galvanized carbon steel with weld-damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.
6. Carbon Steel Finish: Carbon steel bases shall be shot-blasted, cleaned, prepared, and **[painted][or][hot-dip galvanized]** after fabrication.
7. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
 - a. Use welding materials with corrosion properties equal to material being welded.
8. Welding Procedures:
 - a. Structural Welding Codes: **[AWS D1.1/D1.1M for carbon steel][AWS D1.2/D1.2M for aluminum][AWS D1.6/D1.6M for stainless steel]**.
 - b. Join structural members to one another using **[continuous][or][stitch]** welds.
 - c. After welding and fabrication, deburr and grind exposed welds to provide smooth surfaces free of sharp edges.
9. Penetrations through Base Perimeter: Seal **[weld]** pipe, tubing, and conduit penetrations through base perimeter members to provide a watertight assembly.
10. Section Joints: Air-handling units consisting of multiple sections for field assembly shall be joined with structural joining plates.

- a. Joining plate material type to match base.
 - b. Joining plate of thickness required to join sections without resulting in a permanent deflection, minimum [1/2 inch (13 mm)]<Insert dimension> thick.
 - c. Continuously weld joining plates to each mating end of base.
 - d. Joining plates shall not extend beyond outer edge of adjoining base.
 - e. Plates to include at least three equally spaced holes for field connection using factory-furnished threaded hardware of a nominal diameter of at least [1/2 inch (13 mm)]<Insert diameter>.
11. Lifting Provisions: Air-handling unit manufacturer to design and install lifting lugs of size and location required to comply with performance requirements indicated. [**Lifting lugs extending beyond the base shall be easily removable in the field after unit is installed.**]
12. Curb Cap:
- a. For air-handling units installed on a continuous perimeter curb, provide air-handling unit base with a continuous structural angle counterflashing.
 - b. Angle shall extend down vertical face of curb to completely cover wood nailer.
 - c. Coordinate inside dimension of angle counterflashing with curb dimension and roofing. Provide adequate clearance between angle counterflashing and roofing over curb.
- E. Unit Casings:
1. Casing Assembly:
- a. Appearance:
 - 1) Exposed exterior surfaces of casing shall have a neat and finished appearance free of standing seams, exposed reinforcing, and other casing protrusions more than [0.25 inch (7 mm)][0.5 inch (15 mm)]<Insert dimension> beyond the exterior skin surface.
 - 2) Underside of air-handling units with finished installation exposed to view shall have finished appearance matching casing walls. Casing shall be recessed within the perimeter structural base to provide a single contiguous plane.
 - 3) Interior surfaces of casing shall have a neat and finished appearance free of standing seams, exposed reinforcing, and other casing protrusions more than [0.25 inch (7 mm)][0.5 inch (15 mm)]<Insert dimension> beyond the skin surface.
 - b. Dissimilar Metals: Isolate dissimilar metals that are in contact to prevent galvanic action and corrosion.
 - c. Framing and Supports: Interconnect and support individual casing wall and roof panels using either formed panel construction or framed construction with structural support members. For framed casing construction, materials used to construct casing of structural support members shall be as follows:
 - 1) Casings with Aluminum Outer and Inner Skins: Aluminum extrusions in accordance with ASTM B211 Alloy 6063 T6.
 - 2) Casings with Galvanized-Steel Outer and Inner Skins: Galvanized steel.
 - 3) Casings with Galvanized-Steel Outer Skin and Aluminum or Stainless Steel Inner Skins: Stainless steel.
 - 4) Casings with Stainless Steel Outer and Inner Skins: Stainless steel.
 - d. Seals: Seal interior and exterior joints and seams to make casing air- and watertight. Trim factory-applied sealant flush with adjacent surface.
 - e. Double-Wall Casings: Consisting of insulation sandwiched between an outer and inner metal wall. Use double-wall casings to construct air-handling units unless septum casings

- are required.
- f. Septum Casings: Triple-wall construction consisting of a solid metal inner wall sandwiched between insulation layers that are covered with metal walls. Use septum casings for applications having performance requirements that are not achievable with double-wall casings.
 - g. Wall and Roof Penetrations: Seal voids around conduit, piping, and tubing penetrations.
 - 1) Conduit, Pipe, and Tube: Sizes NPS 3 (DN 80) and smaller:
 - a) Seal void through casing with a nonhardening vapor-barrier caulk covered by an escutcheon on both interior and exterior sides of casing. Back caulk using formed insulation within a sheet metal sleeve.
 - b) Seal void using a friction fit neoprene or EPDM sheet material attached to casing using a bed of adhesive.
 - c) Cover penetration and sealing sheet material with metal escutcheon matching adjacent casing material.
 - 2) Larger Conduit, Pipe, and Tube Sizes: Seal annular void using an adjustable compression-type sealing sleeve.
 - h. Floors: Route conduit, pipe, and tube within a floor-mounted pipe sleeve.
 - 1) Sleeve:
 - a) Fabricate sleeve of aluminum[, **galvanized-steel**,] or stainless steel pipe.
 - b) Extend top of sleeve above adjacent floor surface to prevent standing water on floor from entering annular space of sleeve.
 - c) Seal[**weld**] sleeve to top of floor for an air- and watertight seal.
 - d) Seal annular void of sleeve using an adjustable compression seal [or][**nonhardening packing material**].
 - i. Floor Openings with Metal Grating:
 - 1) Factory install walk-on safety gratings over any floor opening large enough to create a safety hazard for operators including, but not be limited to, supply-, return-, and exhaust-air openings.
 - 2) Bar Grating:
 - a) Materials: Use [**stainless steel grating for aluminum**][**stainless steel grating for stainless steel**][**hot-dip galvanized-steel grating for galvanized-steel**][**painted steel grating for painted steel**] floors.
 - b) Air-handling unit manufacturer shall select depth and thickness of grating bars to limit deflection to 1/360 of span when subjected to a dynamic load of not less than [**500 lb (227 kg)**]<Insert weight>.
 - c) Industry-standard welded grating with bars at least **1-1/2 inches (38 mm)** deep by at least **3/16 inch (5 mm)** thick with nominal **1-3/16-inch (30-mm)** main bar spacing and **4-inch (100-mm)** cross bar spacing.
 - d) Source: Product manufacturer specializing in metal gratings.
 - e) Grating bearing surface shall extend beyond clear opening in floor at least [**2 inches (50 mm)**][**3 inches (75 mm)**]<Insert dimension>.
 - 3) Mounting Frame:
 - a) Mount grating in a continuous structural angle or bar frame so no ends of grating bars are exposed. Top of frame to be flush with top of grating.
 - b) Secure grating to frame with threaded hardware so grating does not move

- when walked on but can be easily removed from top to gain access behind grating.
- c) Continuously weld mounting frame to air-handling unit floor.
- d) Fasten mounting frame to air-handling unit floor with hardware and seal attachment air- and watertight.
- e) For applications with automatic dampers installed at floor openings, elevate height of mounting frame and grating to enclose entire damper assembly including jackshaft so walk-on surface of grating is above damper assembly.
- j. Waterproof Floors: Continuously weld floor joints, seams, and penetrations to completely seal floor. Roll all edges of floor up at least **[1 inch (25 mm)]<Insert dimension>** to create a shallow tub capable of holding standing water.
- k. Duct Connections - Direct to Casing: Frame and reinforce unit casing around perimeter of unit duct openings to accommodate direct attachment of field-installed ductwork. Coordinate requirements with Installer to accommodate field connection.
- l. Duct Connections - Elevated Off Casing:
 - 1) Terminate with angle flange face elevated **[3 inches (75 mm)]<Insert dimension>** from exterior surface of casing.
 - 2) Flange Thickness: **[0.25 inch (6 mm)]<Insert dimension>**.
 - 3) Flange face with holes located not more than **[4 inches (100 mm)]<Insert dimension>** o.c., starting at corners, and sized for **[0.375-inch- (9-mm-)]** diameter, field-installed hardware.
 - 4) Size flange face to mate to full face of duct flange.
 - a) Clear inside dimension of unit connection to match clear inside dimension of duct.
 - b) For connections to acoustically lined ducts, increase unit flange face to accommodate thickness of liner so end of duct liner is concealed by air-handling unit flange.
- m. **<Insert requirements>**.
- 2. Materials for Outer Skin of Casing Walls and Roofs:
 - a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating; minimum (nominal) **[18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value>** thick.
 - b. Aluminum Solid Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, **[smooth][stucco-embossed texture][or][leather-grain texture]<Insert finish>** finish; minimum (nominal) **[0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value>** thick.
 - c. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M, **[Type 304][Type 304L][Type 316][Type 316L]<Insert type>**; No. **[2D][or][4]<Insert finish>** finish; minimum (nominal) **[18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value>** thick.
 - d. Application: See Drawings for application of different materials indicated.
- 3. Materials for Inner Skin of Casing Walls and Roofs:
 - a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating, minimum (nominal) **[20 gauge (1.0 mm)][18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value>** thick.
 - b. Galvanized-Steel Perforated Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating, minimum (nominal) **[20 gauge (1.0 mm)][18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value>** thick.

- c. Aluminum Solid Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, [smooth]<Insert finish> finish; minimum (nominal) [0.032 inch (0.8 mm)][0.040 inch (1.1 mm)][0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value> thick.
 - d. Aluminum Perforated Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, [smooth]<Insert finish> finish; minimum (nominal) [0.032 inch (0.8 mm)][0.040 inch (1.1 mm)][0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value> thick.
 - e. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D]<Insert finish> finish; minimum (nominal) [20 gauge (1.0 mm)][18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - f. Stainless Steel Perforated Sheet: ASTM A240/A240M or ASTM A480/A480M; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D]<Insert finish> finish; minimum (nominal) [20 gauge (1.0 mm)][18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - g. Application: See Drawings for application of different materials indicated.
4. Materials for Floor Walking Surface:
- a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; [G90 (Z275)]<Insert coating> coating; minimum (nominal) [14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.5 mm)]<Insert value> thick.
 - b. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M, [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D]<Insert finish> finish; minimum (nominal) [14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.6 mm)]<Insert value> thick.
 - c. Carbon Steel Diamond Treadplate: ASTM A786/A786M, painted finish; minimum (nominal) [0.125 inch (3.2 mm)][0.1875 inch (4.8 mm)]<Insert value> thick.
 - d. Aluminum Diamond Treadplate: ASTM B632/B632M, Alloy 6061 T6; mill finish; minimum (nominal) [0.125 inch (3.2 mm)][0.1875 inch (4.8 mm)]<Insert value> thick.
 - e. Stainless Steel Diamond Treadplate: ASTM A793; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; mill finish; minimum (nominal) [0.125 inch (3.2 mm)][0.1875 inch (4.8 mm)]<Insert value> thick.
 - f. Application: See Drawings for application of different materials indicated.
5. Materials for Underside of Floor Insulation:
- a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; [G90 (Z275)]<Insert coating> coating; minimum (nominal) [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - b. Aluminum Solid Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, [smooth]<Insert finish> finish; minimum (nominal) [0.040 inch (1.1 mm)][0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value> thick.
 - c. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D][4]<Insert finish> finish; minimum (nominal) [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - d. Application: See Drawings for application of different materials indicated.
6. Materials for Internal Walls:
- a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; [G90 (Z275)]<Insert coating> coating; minimum (nominal) [16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.
 - b. Aluminum Solid Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, smooth finish; minimum (nominal) [0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value> thick.
 - c. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M, [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. 2D finish; minimum (nominal) [16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.
 - d. Application: See Drawings for application of different materials indicated.

7. Surfaces in Contact with Airstream:
 - a. Comply with ASHRAE 62.1 and NFPA 90A.
 - b. Glass or mineral-fiber insulation installed behind perforated metal shall be encapsulated to prevent insulation fibers from entering the airstream by using a **[polymer sheet material][or][tightly woven glass cloth material that does not impact the acoustical absorption properties of insulation]**.
8. Insulation for Casing Walls and Roofs Not Exposed to Airstream:
 - a. Materials Not Exposed to Airstream: **[Glass or mineral-fiber board][injected or sprayed polyurethane foam][or][polyurethane foam board]** insulation with a minimum nominal density of **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)]<Insert density>**.
 - b. R-Value: Minimum **[R-8][R-10][R-12][R-16]<Insert value>**.
 - c. Thickness: Minimum **[2 inches (50 mm)][2.5 inches (68 mm)][3 inches (75 mm)][4 inches (100 mm)]<Insert dimension>**.
 - d. Insulation shall completely fill the casing cavity so no voids exist.
9. Insulation for Casing Walls and Roofs Exposed to Airstream:
 - a. Materials Exposed to Airstream: Glass or mineral-fiber board insulation with a minimum density of **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density>**.
 - b. R-Value: Minimum **[R-8][R-10][R-12][R-16]<Insert value>**.
 - c. Thickness: Minimum **[2 inches (50 mm)][2.5 inches (68 mm)][3 inches (75 mm)][4 inches (100 mm)]<Insert dimension>**.
 - d. Insulation shall completely fill the casing cavity so no voids exist.
10. Insulation for Casing Floors:
 - a. Materials: **[Glass or mineral-fiber board insulation][injected or sprayed polyurethane foam][or][polyurethane foam board]** insulation with a minimum nominal density of **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)]<Insert density>**.
 - b. R-Value: Minimum **[R-8][R-10][R-12][R-16]<Insert value>**.
 - c. Thickness: Minimum **[2 inches (50 mm)][2.5 inches (68 mm)][3 inches (75 mm)][4 inches (100 mm)]<Insert dimension>**.
 - d. Insulation shall completely fill the casing cavity so no voids exist.
11. Access Doors:
 - a. Application: **[Install access doors in air-handling units at locations indicated on Drawings][Install access doors downstream and upstream of all internal components]<Insert requirement>**.
 - b. Adjustment: Design doors for field adjustment capable of maintaining specified leakage rate.
 - c. Mounting Height: Install bottom of door frame within **[2 inches (50 mm)]<Insert dimension>** of air-handling unit floor walking surface. **[Where internal conditions require access doors to be mounted higher above air-handling unit floor, include permanent retractable stairs inside and outside of air-handling unit to limit stair risers to 6 inches (150 mm).]**
 - d. Performance: Leakage as required to satisfy overall unit leakage performance indicated, but not more than **[1.0 cfm (0.47 L/s)]<Insert leakage rate>** per door when tested at **10 inches wg (2500 kPa)**.
 - e. Fabrication: Formed and reinforced, constructed of same materials and thicknesses as casing. **[Where doors are installed in casing walls with perforated interior, install**

- doors with solid interior.]**
- f. Swing: Arrange doors to be opened against pressure, unless otherwise indicated on Drawings.
 - g. Frame: **[Extruded aluminum with thermal break][galvanized steel][or][stainless steel]** with **[welded]** mitered corners.
 - h. Handles:
 - 1) Secure door closed using not less than two **[roller-style]** latches with handles located at quarter points along door height.
 - 2) If three latches with handles are included, install one at midpoint of door height and equally space others.
 - 3) Air-handling unit manufacturer has option to use a multipoint latching mechanism that is operable from a single door handle located at midpoint of door height, but secures door to frame at top, bottom, and handle location.
 - 4) Include door handles on outside and inside of door to allow operator access to open and close door from outside and inside of unit.
 - 5) Field adjustable to accommodate changes to fit and gasket compression.
 - 6) Durable product capable of withstanding repeated opening and closing of door while operating under design pressure without damage.
 - i. Hinges: **[Minimum of two hinges][minimum of three hinges][or][full-length, concealed, stainless steel piano hinge]**.
 - j. Gasket:
 - 1) Design: Specially formed with an internal air chamber specifically designed to seal on two surfaces without taking a permanent set.
 - 2) Dual Gaskets: Primary and secondary gasket.
 - 3) Location: Install gaskets around entire perimeter of doors or frames.
 - 4) Material: EPDM, neoprene, or santoprene.
 - 5) Protection: Seat gasket in a protective metal ribbed chamber integral to door or door frame to protect gasket from damage by operator incidental contact.
 - 6) Service: Field replaceable.
 - 7) Adhesive-backed tape-type gaskets adhered to a single flat surface are unacceptable.
 - k. Size of Door Frame Clear Opening: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.
 - 1) Width: At least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** clear inside of door frame.
 - 2) Height: Full clear height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>** clear inside of door frame.
 - 3) Door sizes indicated on Drawings.
 - l. Safety Latches and Stops:
 - 1) Safety Latches: Install safety latch with retainers on outward swing doors that do not open against pressure to allow restricted travel for purpose of pressure relief and so that doors do not open uncontrollably due to inside pressure.
 - 2) Stops: Install cushioned door stops on inward swinging doors where necessary to limit door travel that could potentially damage the door or internal components.
 - m. Tie-Backs: Install tie-backs with retainers on **[outward-swinging]** access doors to hold doors in an open position during service.
 - n. Locks: Include each access door with an integral key lock. Pad locks are unacceptable.

- 1) Incorporate key lock into door handle where feature is available.
 - 2) A common key shall be used to lock and unlock access doors of **[each][all]** air-handling unit(s).
 - 3) Include **[two]<Insert value>** keys **[for each air-handling unit]**.
 - 4) Lock access doors at factory to ensure that unauthorized access is in place before air-handling unit packaging and shipment.
- o. Windows:
- 1) Construction: Fabricate windows with frame mounted in access doors of double-glazed safety glass with an airspace between panes and interior and exterior seals.
 - 2) Condensation Control: Install desiccant material in airspace between panes if necessary to prevent condensation from forming on glazing.
 - 3) Clear Viewing Size: Minimum **[6 inches (150 mm)][8 inches (200 mm)][12 inches (300 mm)]<Insert dimension>**, square **[or round]**.
 - 4) Mounting Location: Center window in door width. For doors up to **[60 inches (1500 mm)]<Insert dimension>** high, locate top of window **[6 inches (150 mm)]<Insert dimension>** below top of door. For taller doors, locate center of windows at optimal viewing height, approximately **[60 inches (1500 mm)]<Insert dimension>** above floor adjacent to unit.
 - 5) Application: Install windows in **[all access doors][only access doors servicing fans][only access doors servicing fans and filters][only access doors servicing coils, dampers, heat wheels, fans, filters, and UV-C lamps]<Insert requirement>**.
- p. Nameplates:
- 1) On each access door, include a nameplate defining the access to service within. Nameplates shall be included for, but not be limited to, the following:
 - a) Dampers.
 - b) Filters.
 - c) Gas-phase filters.
 - d) Cooling coils.
 - e) Heating coils.
 - f) Electric heaters.
 - g) Duct silencers.
 - h) Heat wheels.
 - i) Fixed plate exchangers.
 - j) Heat pipe heat exchangers.
 - k) UV-C lamp systems.
 - l) Supply fans.
 - m) Exhaust fans.
 - n) Return fans.
 - o) Humidifiers.
 - p) Air blenders.
 - q) **<Insert items>**.
 - r) Air-handling unit designation.
 - s) Where door access is to multiple components, list all components accessed. For example: Filter/Cooling Coil.
 - t) For each door that does not open against static pressure, include a warning sign stating: "DANGER: DOOR UNDER PRESSURE. DO NOT OPEN WITH FAN ON."
 - 2) Lettering Size and Style: At least **[1-inch- (25-mm-)]<Insert dimension>** high, block

- style.
- 3) Material: Lettering engraved in black plastic on a white plastic back. Engraving shall penetrate through black plastic so lettering reads white.
 - 4) Attachment: Attach nameplates to door using high-strength bonding cement and **[stainless steel]**screws.
 - 5) Mounting Location:
 - a) For access doors without windows, locate top of nameplate **[6 inches (150 mm)]<Insert dimension>** from top of door and center in door width.
 - b) For access doors with windows, locate nameplate directly **[above][or][below]** window frame and center in door width.
 - c) Align nameplates of all doors for uniform placement.
12. Access Door Gutters and Downspouts: Install rain gutters directly above each access door to deflect rain away from doors.
- a. Construct gutters of same materials and finish as casing exterior.
 - b. Extend gutters beyond vertical edge of doors at least **[3 inches (75 mm)]<Insert dimension>**.
 - c. Install gutter with a downspout located adjacent to access door frame. Construct downspout of **[aluminum][or][stainless steel]** pipe **[or][copper tube]** of a size determined by unit manufacturer. Terminate downspout at a height below unit floor.
13. Access Panels:
- a. Performance: Leakage as required to satisfy overall unit leakage performance indicated.
 - b. Fabrication: Formed and reinforced panels of same material and thickness as casing.
 - c. Fasteners: Adjustable, reusable type for multiple operations without degradation due to reuse. **[Do not use screws capable of stripping.]**
 - d. Arrangement: Panels removable from exterior side of casing.
 - e. Gasket: EPDM, neoprene, or santoprene similar to access doors, applied around entire perimeter of panels or frames.
 - f. Location and Size:
 - 1) Coils: Oversized access panel to allow removal and replacement without impacting adjacent casing.
 - 2) Electric Heaters: Oversized access panel to allow removal and replacement without impacting adjacent casing.
 - 3) Fans: Oversized access panel to allow removal and replacement of entire fan assembly **[including base]**without impacting adjacent casing.
 - 4) Heat Wheels and Heat Exchangers: Oversized access panel to allow removal and replacement of internal components without impacting adjacent casing.
 - 5) Humidifiers: Oversized access panel to allow removal and replacement without impacting adjacent casing.
 - 6) **<Insert component>**.
 - g. Nameplates:
 - 1) On each access panel, include a nameplate defining the access to service within. Nameplates shall be included for, but not be limited to, the following:
 - a) Cooling coils.
 - b) Heating coils.
 - c) Electric heaters.
 - d) Heat wheels.
 - e) Fixed plate exchangers.

- f) Heat pipe heat exchangers.
 - g) Humidifiers.
 - h) Supply fans.
 - i) Exhaust fans.
 - j) Return fans.
 - k) <Insert description>.
14. Standing-Seam Metal Roof: Construct air-handling unit roof casing with standing seams designed for waterproof roofing applications.
- a. Construct air-handling unit roof using same materials and finish as walls.
 - b. Slope roof away from primary access side of unit at not less than [1][2]<Insert number> percent.
 - c. For air-handling units shipped in multiple sections, include standing-seam joiners at each split with adhesive, hardware, and cover strips for field joining by Installer.
15. Roofing Membrane:
- a. Cover entire roof with a roofing membrane. Extend membrane down sides of unit a sufficient distance to provide a waterproof roof assembly and secure in place with a metal flashing matching casing material and finish.
 - 1) Roofing membrane shall have an elongation of at least 450 percent when tested in accordance with ASTM D412.
 - 2) Roofing membrane shall not become brittle at temperatures down to minus **40 deg F (40 deg C)**.
 - b. Slope unit roof away from primary access side of unit at a slope in accordance with roofing manufacturer's written instructions, but not less than [1][2]<Insert number> percent.
 - c. Application: Factory or field applied as determined by air-handling unit manufacturer; in accordance with roof manufacturer's written instructions.
 - 1) Field-applied roofing to be supervised by an air-handling unit manufacturer's factory service representative.
16. Liquid-Applied Roofing:
- a. Cover entire roof with a liquid-applied roofing. Extend liquid-applied roofing down sides of unit a sufficient distance to provide a waterproof roof assembly and cover sides with a metal flashing matching casing material and finish.
 - 1) Cured roofing shall have an elongation of at least 500 percent at **77 deg F (25 deg C)** and at least 300 percent at **0 deg F (minus 17 deg C)**, when tested in accordance with ASTM D412.
 - 2) Roofing shall not become brittle at temperatures down to minus **40 deg F (40 deg C)**.
 - b. Slope unit roof away from primary access side of unit at a slope in accordance with roofing manufacturer's written instructions, but not less than [1][2]<Insert number> percent.
 - c. Application: Factory or field applied as determined by air-handling unit manufacturer; in accordance with roof manufacturer's written instructions.
 - 1) Field-applied roofing to be supervised by an air-handling unit manufacturer's factory service representative.

17. Service Corridors:

- a. Description: Integral walk-in service corridors with [heated][and][cooled][ventilated] temperature-controlled indoor environment for weather-protected service access to unit access doors and factory-installed [piping][electrical][and][controls].
- b. Size and Arrangement: [As indicated on Drawings][Full length of unit by 6 feet (2 m) deep]<Insert requirements>.
- c. Construction: Base, floor, walls, and roof to match air-handling unit.
- d. Access Doors:
 - 1) Width: Minimum [36-inch (900-mm)][42-inch (1050-mm)]<Insert dimension> clear inside frame opening.
 - 2) For double-door applications, include door frames with removable center mullions for unrestricted access.
- e. Electrical: Factory install and wire [service lights with switches][and][receptacles].
- f. Indoor Environmental Control: Factory install [self-contained, packaged]HVAC equipment required to thermostatically controlled indoor environment to maintain following indoor conditions:
 - 1) Minimum Temperature: <Insert temperature>.
 - 2) Maximum Temperature: <Insert temperature>.
 - 3) Maximum Coincident Relative Humidity: [60]<Insert number> percent.
- g. Field Connections to Factory-Installed Piping, Electrical, and Controls: Arranged to make field connections to factory terminations inside of service corridor and within <Insert distance> of floor walking surface. Frame openings in air-handling unit floor to accommodate field connections.

18. Piping Enclosures:

- a. Description: Integral accessible enclosure(s) to house field-installed piping from below and connecting to hydronic [and steam]coils[and steam humidifiers].
- b. Size: Adequate clearance for field installation of piping, valves, accessories, and associated insulation.
 - 1) Maintain at least [6 inches (150 mm)]<Insert dimension> of clearance between inside of enclosure and face of pipe insulation at most restricted point.
- c. Construction:
 - 1) Base, Walls, and Roof: Match air-handling unit.
 - 2) Floor: Not required, open to below.
 - 3) Access Doors:
 - a) Size for full front access to piping, valves, and accessories installed within enclosure.
 - b) Double-door applications with removable center mullions for unrestricted access.
- d. Electrical: Factory install and wire [service light with switch][and][receptacle] for each enclosure.

F. Wall Louvers:

- 1. Wall Louvers, Drainable Blade:



- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Pottorff]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Pottorff]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain louvers from single source from single manufacturer.
- d. Performance:
 - 1) Air Pressure Drop, Design: Less than **[0.1 inch wg (2.5 Pa)]<Insert pressure drop>** at airflow indicated on Drawings.
 - 2) Air Pressure Drop, Rating: Less than **0.1 inch wg (2.5 Pa)** at free area intake face velocity of **700 fpm (3.6 m/s)**.
 - 3) Face Velocity: If louver size is not indicated on Drawings, size louver for **[500-fpm (2.5-m/s)]<Insert value>** velocity across louver free area.
 - 4) Free Area: 54 percent or more for a **48-by-48-inch (1200-by-1200-mm)** representative sample.
 - 5) AMCA 500-L: Beginning point of water penetration at **870 fpm (4.4 m/s)**.
- e. Features:
 - 1) Depth: **4 inches (100 mm)**.
 - 2) Frame: **0.080 inch (2 mm)** thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy.
 - 3) Blades: **0.080 inch (2 mm)** thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy; stationary in horizontal position, drainable.
 - 4) Stationary vertically positioned blades.
 - 5) Bird Screen: **0.5-by-0.040-inch (13-by-1.0-mm)** expanded flattened aluminum attached to back of louver.
 - 6) Finish: Match exterior casing.
- f. Air-Handling Unit Factory Assembly:
 - 1) Install louver face flush with exterior of casing and seal to provide a weathertight installation.
 - 2) Secure louver in casing and include additional bracing if required to handle loading of extreme outdoor environmental performance indicated.
- g. Application: Factory install louvers in air-handling casing **[at locations indicated on Drawings][for each outdoor intake][for each outdoor intake and exhaust discharge]**.

2. Wall Louvers, Wind-Driven Rain:

- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- 1) [Greenheck Fan Corporation]
 - 2) [Pottorff]
 - 3) [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - 4) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [Greenheck Fan Corporation]
 - 2) [Pottorff]
 - 3) [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - 4) <Insert manufacturer's name>
- c. Source Limitations: Obtain louvers from single source from single manufacturer.
- d. Performance:
- 1) Air Pressure Drop, Design: Less than [0.1 inch wg (2.5 Pa)]<Insert pressure drop> at airflow indicated on Drawings.
 - 2) Air Pressure Drop, Rating: Less than 0.1 inch wg (2.5 Pa) at free area intake face velocity of 800 fpm (4.1 m/s).
 - 3) Face Velocity: If louver size is not indicated on Drawings, size louver for [500-fpm (2.5-m/s)]<Insert value> velocity across louver free area.
 - 4) Free Area: 47 percent or more for a 48-by-48-inch (1200-by-1200-mm) representative sample.
 - 5) AMCA 500-L:
 - a) Wind-Driven Rain Penetration Class: Class A, with wind-driven rain penetration effectiveness of 99 percent at core velocity up to [408 fpm (2.1 m/s)]<Insert velocity> with 50-mph (80-kph) wind and rainfall of 8 inches (200 mm) per hour.
 - b) Intake Discharge Loss Class: Class 2.
- e. Features:
- 1) Depth: 5 inches (125 mm).
 - 2) Frame: 0.080 inch (2 mm) thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy.
 - 3) Blades: 0.063 inch (1.6 mm) thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy; stationary in horizontal position, double drainable, and sightproof.
 - 4) Stationary vertically positioned blades.
 - 5) Bird Screen: 0.5-by-0.040-inch (13-by-1.0-mm) expanded flattened aluminum attached to back of louver.
 - 6) Finish: Match exterior casing.
- f. Air-Handling Unit Factory Assembly:
- 1) Install louver face flush with exterior of casing and seal to provide a weathertight installation.
 - 2) Secure louver in casing and include additional bracing if required to handle loading of extreme outdoor environmental performance indicated.

- g. Application: Factory install louvers in air-handling casing **[at locations indicated on Drawings][for each outdoor intake][for each outdoor intake and exhaust discharge]**.
3. Wall Louvers, Hurricane Rated:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1) **[Greenheck Fan Corporation]**
 - 2) **[Pottorff]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[Greenheck Fan Corporation]**
 - 2) **[Pottorff]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain louvers from single source from single manufacturer.
- d. Certification: Miami-Dade Notice of Acceptance.
- e. Performance:
- 1) Air Pressure Drop, Design: Less than **[0.1 inch wg (2.5 Pa)]<Insert pressure drop>** at airflow indicated on Drawings.
 - 2) Air Pressure Drop, Rating: Less than **0.1 inch wg (2.5 Pa)** at free area face velocity of **1500 fpm (7.5 m/s)**.
 - 3) Face Velocity: If louver size is not indicated on Drawings, size louver for **[500-fpm (2.5-m/s)]<Insert value>** velocity across louver free area.
 - 4) Free Area: 33 percent for a **48-by-48-inch (1200-by-1200-mm)** representative sample.
 - 5) AMCA 500-L, Wind-Driven Rain Penetration Class: Class A, with wind-driven rain penetration effectiveness of 100 percent at core velocity up to **[960 fpm (4.9 m/s)]<Insert velocity>** with **50-mph (80-kph)** wind and rainfall of **8 inches (200 mm)** per hour.
 - 6) AMCA 540 and AMCA 550: Listed.
 - 7) Wind Loading: Positive **160 psf (7.66 kPa)**, negative **140 psf (6.7 kPa)**.
- f. Features:
- 1) Depth: **6 inches (150 mm)** nominal.
 - 2) Frame: **0.095 inch (2.4 mm)** thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy.
 - 3) Blades: **0.080 inch (2.1 mm)** thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy; stationary in vertical position.
 - 4) Bird Screen: **0.5-by-0.063-inch (13-by-1.6-mm)** expanded flattened aluminum attached to back of louver in a removable frame.
 - 5) Finish: Match exterior casing.
- g. Air-Handling Unit Factory Assembly:

- 1) Install louver face flush with exterior of casing and seal to provide a weathertight installation.
 - 2) Secure louver in casing and include additional bracing if required to handle loading of extreme outdoor environmental performance indicated.
- h. Application: Factory install louvers in air-handling casing **[at locations indicated on Drawings][for each outdoor intake][for each outdoor intake and exhaust discharge]**.

G. Internal Structural Supports:

1. General:
 - a. Air-handling unit manufacturer shall design and assemble air-handling unit internal structural supports for attachment and support by air-handling unit structural base.
 - b. Factory install structural supports for internal support casing if required to comply with casing structural performance.
 - c. Factory install hoist beams and rails over equipment to comply with performance requirements for service.
2. Structural Member Size and Spacing:
 - a. Size: Air-handling unit manufacturer shall select size of members and construction to do the following:
 - 1) Withstand the rigors of loading, unloading, shipping and rigging without damage to air-handling unit components or misalignment of factory-assembled casing and components.
 - 2) Comply with performance requirements indicated.
 - b. Spacing: Positioned as required to comply with requirements.
3. Materials: **[Structural aluminum, ASTM B209 (ASTM B209M), Alloy 6061 T6][Structural carbon steel, ASTM A36/A36M][Structural stainless steel, ASTM A276/A276M, Type 304L][or][structural stainless steel, ASTM A276/A276M, Type 316L][as indicated on Drawings]**.
 - a. Structural Supports: **[Angle][channel][I or W beam shapes][or][tube]** shapes selected by air-handling unit manufacturer for application.
 - b. Hoist Beams for Internal Components (Spanning Full Width of Unit): I or W beam shapes.
4. Carbon Steel Finish, Mill Galvanized: Mill-galvanized carbon steel with weld damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.
5. Carbon Steel Finish: Carbon steel bases shall be shot-blasted, cleaned, prepared, and **[painted][or][hot-dip galvanized]** after fabrication.

H. Factory-Manufactured Roof Curbs:

1. General:
 - a. Air-handling unit manufacturer shall furnish a continuous perimeter curb for **[each][each roof-mounted]<Insert requirement>** air-handling unit.
 - b. Design curb to support operating air-handling unit from its base with attachments to withstand environmental forces. Curbs with intermediate reinforcing as required.
 - c. Frame curb for ductwork, piping, and conduit located within curb.
 - d. Fabricate curb to maintain top of curb level even where installed on sloping substrate.
 - e. Furnish top of curb to provide for field attachment of unit base to curb.

- f. Furnish curb with a fully mitered and raised cant where required by adjacent insulation and roofing.
 - g. Include bottom of curb with attachment flange that extends beyond base of curb and is suitable for attachment to substrate.
 - h. Furnish curb with integral crickets if required by roof installation.
- 2. Size:
 - a. Size curb to provide continuous support of unit base and to fit within footprint of unit perimeter base.
 - b. Height:
 - 1) See Drawings.
 - 2) **[12 inches (300 mm)][18 inches (450 mm)]<Insert dimension>** from top of curb to finished roofing surface at highest point along perimeter of curb.
- 3. Materials:
 - a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating; minimum (nominal) **[14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.5 mm)]<Insert value>** thick. Treat welded areas to protect against corrosion with a zinc-rich coating.
 - b. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M, **[Type 304][Type 304L][Type 316][Type 316L]<Insert grade>** grade; No. **[2D]<Insert finish>** finish; minimum (nominal) **[14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.6 mm)]<Insert value>** thick.
- 4. Insulation:
 - a. Insulate curb to provide thermal performance equal to unit casing.
 - b. Completely encapsulate insulation within metal curb.
- 5. Gaskets:
 - a. Include a continuous gasket between air-handling unit base and top of curb for an air and watertight seal.
 - b. Select gasket materials suitable for installation while complying with requirements indicated.
 - c. Furnish gasket materials with air-handling units and curbs for field installation.
 - d. Air-handling unit manufacturer to provide instruction to installer on proper installation techniques.
- I. Centrifugal Fan Arrays:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ebm-papst Inc.]**
 - b. **[Greenheck Fan Corporation]**
 - c. **[Lau Fan]**
 - d. **[Loren Cook Company]**
 - e. **[Rosenberg USA, Inc.]**
 - f. **[Twin City Fan & Blower]**
 - g. **[ZIEHL-ABEGG Inc.]**

- h. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ebm-papst Inc.]
 - b. [Greenheck Fan Corporation]
 - c. [Lau Fan]
 - d. [Loren Cook Company]
 - e. [Rosenberg USA, Inc.]
 - f. [Twin City Fan & Blower]
 - g. [ZIEHL-ABEGG Inc.]
 - h. <Insert manufacturer's name>
- 3. Sourcing Option: In lieu of sourcing fan array assemblies from a specialty fan manufacturer, air-handling unit manufacturer has option to furnish in-house fan array assemblies that achieve equal or better performance while complying with other requirements indicated.
- 4. Operating Performance:
 - a. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - 1) Add additional static pressure to fan scheduled total static pressure.
 - 2) If fan motor horsepower is increased, notify Architect.
 - b. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.
 - c. Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.
 - d. Scheduled motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
 - e. At a minimum, fans shall have AMCA class indicated on Drawings.
 - 1) Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.
 - 2) If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - 3) AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.
 - f. Motor starting torque shall exceed fan speed-torque requirements.
 - g. Airflow Profile:
 - 1) Fan arrangement within fan array shall produce a uniform airflow and velocity profile across air-handling unit air tunnel when measured [12 inches (300 mm)]<Insert dimension> upstream of fan inlet and [48 inches (1200 mm)]<Insert dimension> downstream of fan inlet.
- 5. Vibration Balance:
 - a. Each fan/motor assembly shall be factory balanced to AMCA 204, [BV-5, Balance Quality Grade G1.0][BV-4, Balance Quality Grade G2.5][BV-3, Balance Quality Grade G6.3][Balance Quality Grade indicated on Drawings]<Insert fan vibration balance requirements> or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed



- to be [10][20]<Insert number> percent of design speed.
 - b. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 - c. Submit test reports as an informational submittal for Project record.
6. Vibration Isolation: Install vibration isolation on each fan/motor assembly in the fan array, except vibration isolation may be omitted on fans/motor assemblies balanced to AMCA 204, BV-5, with a maximum residual imbalance of **0.22-in./s (5.6-mm/s)** peak, filter in.
7. Operation and Service Requirements:
- a. Remaining fans in array shall continue to operate with one or multiple failed fans.
 - b. Each fan/motor assembly of fan array shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in the array.
 - c. Each fan/motor assembly shall be controlled through a variable-frequency controller, except for fans with electronically commutated (EC) motors having integral motor controls.
 - 1) Include a dedicated variable-frequency controller for each fan/motor assembly in the fan array.
 - 2) If fan array is served from a single variable-frequency controller, include a redundant variable-frequency controller with automatic switchover in event of primary variable-frequency controller failure.
 - d. A single mechanical, electrical, and control device failure shall not result in a fan array available capacity of less than [33]<Insert number> percent of air-handling unit total scheduled airflow capacity.
 - e. Fan wheel/motor assembly shall pass through the air-handling unit access door servicing fans. Entire individual fan assembly shall pass through the door to the room where air-handling unit is located.
 - f. Design and incorporate features to permit safe, rapid, and economical maintenance.
8. Airflow Measurement, Local Indication, and Remote Monitoring:
- a. Each fan within fan array shall include airflow measurement indication in **cfm (L/s)**.
 - b. Include airflow totalization of all operating fans in fan array.
 - c. Airflow measurement instrumentation shall not restrict or deflect air travel through fan and shall not impact fan air and sound performance.
 - d. Include digital display of individual fan airflow and total fan array airflow on face of fan control panel.
 - e. Include a 4- to 20-mA output signal for remote monitoring of total fan array airflow.
9. Fan Array Local Control:
- a. Include fan control panel with operator interface to control fan array locally through the fan control panel and to switch to control of fan array through a remote-control source.
 - b. Local control shall include on/off operation [**and speed adjustment**] for entire fan array and each individual fan/motor in fan array.
10. Fan Array Remote Control:
- a. Include fan control panel with control interface for remote control.
 - b. Fan array on/off operation shall be remotely controlled through a single hardwired digital output signal.
 - c. Fan array speed shall be remotely controlled through a single hardwired analog (4- to 20-mA) output signal.

11. Fan Base, Stackable Fan Units:
 - a. Mount fan/motor on **[aluminum][galvanized-steel][or][powder-coated steel]** base.
 - b. Include base and vibration isolators in accordance with requirements indicated.
 - c. Weld structural members to form a rigid base.
 - d. Size and design the base construction to withstand the rigors of shipping and rigging.
 - e. Include the base with lifting lugs or holes.
12. Fan Frame:
 - a. Construct frame of **[aluminum][galvanized-steel][or][powder-coated steel]**.
 - b. Reinforce and brace frame to prevent excessive deflection and pulsation.
 - c. Include stiffeners to form a rigid frame that is free of structural resonance and vibration.
13. Fan Panel:
 - a. Construct fan panel of **[continuously welded][aluminum][galvanized steel][or][powder-coated steel]**.
 - b. Reinforce and brace fan panel to prevent excessive deflection and pulsation.
 - c. Include stiffeners to form a rigid panel that is free of structural resonance and vibration.
14. Fan Inlet Cone:
 - a. Include a precision-spun or die-formed, matched inlet and wheel cone to ensure streamlined airflow into the wheel and full loading of fan blades.
 - b. Inlet cone shall be a smooth hyperbolic shape.
 - c. Inlet cone shall be a single piece, constructed of aluminum or powder-coated steel.
 - d. Fasten inlet cone to fan panel using bolts, nuts, and washers to provide a positive and secure attachment that can be field removable.
15. Fan Wheel:
 - a. Fan blades shall be a true hollow airfoil shape, welded to backplate and wheel cone.
 - b. Construct blades of aluminum, reinforced for AMCA fan class.
 - c. Design blades to provide smooth airflow over all surfaces of blade.
 - d. Construct fan hubs of aluminum with integral bracing for extra strength and stiffness.
 - 1) Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.
 - 2) Clean surfaces of castings by blasting, pickling, or any other standard method.
 - 3) Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.
 - 4) Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.
 - e. Hubs shall be keyed and setscrewed to motor shaft for positive attachment.
 - f. Construct wheel backplates of aluminum.
 - g. Select entire rotating assembly so first critical speed is at least **[30]<Insert number>** percent greater than fan design speed and at least **[20]<Insert number>** percent greater than maximum speed in AMCA fan class.
16. Fan Drive:
 - a. Direct drive, arrangement 4 in accordance with AMCA 99.
 - b. Adjust wheel width and diameter to match motor speed while providing performance scheduled.



- c. Fasten fan wheel directly to motor shaft using a key in motor shaft and setscrew.
 - d. Construct motor base and pedestal supports of **[aluminum][galvanized steel][or][powder-coated steel]**.
 - e. Fan Speed Limitation:
 - 1) Fan speed at design conditions indicated shall not exceed speed on motor nameplate.
 - 2) Do not select fans to operate at motor speeds greater than motor nameplate.
17. Fan Motors: See "Fan Motors" Article for ac motors.
18. Fan Motors, Electronically Commutated (EC):
- a. Description: EC, variable-speed, dc, programmable brushless motor.
 - b. Features:
 - 1) Integral controller/inverter operates wound stator and senses rotor position to electronically commute the stator.
 - 2) Controller shall control motor speed either through manual adjustment locally at fan array control panel or through a remote 0- to 10-V-dc control signal.
 - 3) Motor Mounting: Coordinate with driven equipment; suitable for mounting with motor shaft in either horizontal or vertical position.
 - c. Performance:
 - 1) Altitude: Suitable for operation at site altitude.
 - 2) Electrical Characteristics: Suitable for operation with field power source. Coordinate with electrical Installer.
 - 3) Energy Efficiency: Complying with governing energy codes; **[80]<Insert number>** percent or higher maintained throughout entire operating range.
 - 4) Power Factor: **[0.9]<Insert value>** or higher at full load.
 - 5) Service Factor: 1.0 or higher.
 - 6) Speed Control: Variable, zero to 100 percent.
 - a) Synchronous speed rotation with no slip losses.
 - b) Gradual ramp-up to set point upon receiving a start signal.
 - c) Soft speed change ramps.
 - d) Able to overcome reverse rotation without impact.
 - e) Control airflow within 5 percent of set point regardless of static pressure.
 - 7) Temperature: Suitable for operation in ambient temperature range encountered.
 - 8) Thermal Protection:
 - a) Automatically breaks electrical power to motor when temperature exceeds a safe value.
 - b) Automatically resets and restores power when temperature returns to normal range.
 - d. Bearings: Sealed and permanently lubricated ball bearings.
 - e. Enclosure: ODP or TEFC.
 - f. Insulation: Class B or Class F.
 - g. Rotor: Permanent magnet with near zero rotor losses that operates independent of motor current.
 - h. Materials and Construction:
 - 1) Enclosure and Frame: Aluminum, painted steel, or stainless steel.

- 2) End Brackets: Cast aluminum.
- 3) Shaft: Steel or stainless steel.
- 4) Motor Leads: Pin or screw terminals.
- 5) Nameplates: Manufacturer's standard.
- 6) Paint: Manufacturer's standard.

19. Fan Enclosure:

- a. Include each fan in fan array with integral single-wall enclosure constructed of solid **[aluminum][galvanized-steel][or][powder-coated steel]** sheet.
- b. Enclosure shall not increase fan array length beyond size indicated on Drawings.
- c. Enclosure shall not add static pressure loss.
- d. Enclosure shall provide a physical separation between operating adjacent fans to prevent negative performance.

20. Fan Sound Silencing Enclosure:

- a. Include each fan of fan array with integral sound silencer enclosure to reduce the bare fan discharge sound levels by at least **[8][15]<Insert value>** dB through octave band frequencies from 125 to 8000 Hz.
- b. Enclosure shall not increase the fan array length beyond size indicated on Drawings.
- c. Silencing enclosure shall not add static pressure loss.
- d. Double-wall construction consisting of sound absorbing insulation sandwiched between a solid metal outer skin and perforated metal inner skin.
 - 1) Outer Skin Material: **[Aluminum][Galvanized steel][Powder-coated steel]**.
 - 2) Inner Skin: Material **[Aluminum][Galvanized steel][Powder-coated steel]**.
 - 3) Insulation Material: **[Mineral fiber][mineral fiber wrapped in a tight woven fiberglass cloth or polymer sheet][or][fiber free]**.
- e. Enclosure shall provide a physical separation between operating adjacent fans to prevent a negative performance.

21. Backdraft Damper:

- a. Include each fan in the fan array with a backdraft damper at the fan **[inlet][or][outlet]** to prevent air circulation through a fan that is not operating.
- b. Open backdraft damper when fan is operating and close when fan is not operating.
- c. Design backdraft damper assembly to operate with little to no static pressure loss with fan operating throughout entire operating range from design to minimum airflow.
 - 1) Add damper pressure loss shall to fan scheduled total static pressure.
 - 2) If pressure loss requires a change field electrical power, air-handling unit manufacturer shall be responsible for associated cost of change.
- d. Fasten backdraft damper assembly to fan panel or enclosure using hardware designed for easy removal by maintenance personnel.
- e. Dampers shall not create measurable additional noise above the sound level of fan.
- f. Dampers shall not vibrate or rattle.
- g. Construct dampers of extruded aluminum, stainless steel, or powder-coated steel.

22. Blank-off Panels:

- a. Include **[one][two][10 percent of]<Insert number>** blank-off panel(s) with each air-handling unit fan array for use by operators in the field to prevent air circulation through any of the fans in fan array that are not operating.

- b. Design blank-off panels for attachment to fan panels using easily removable and reusable hardware.
 - c. Construct blank-offs of aluminum, stainless steel, or powder-coated steel sheets, not less than **[0.07 inch (1.8 mm)]<Insert dimension>** thick.
 - d. Mount fan blank-off panels in the fan inlet access section for convenient operator access and use in the future.
23. Protective Screens:
- a. Include easily removable safety screens where fan inlet and outlet are exposed to maintenance personnel, including walk-in air-handling unit plenums.
 - 1) Safety screens are not required on fan inlets and outlets with backdraft dampers.
 - b. Expanded-metal or wire screens, fastened to a flat bar perimeter frame.
 - c. Screens shall comply with OSHA requirements.
 - d. Screens and frame shall be constructed of aluminum, stainless steel, or powder-coated steel.
 - e. Fasten screens to fan using removable and reusable hardware designed for easy removal by maintenance personnel.
24. Hardware: Hex-head, high-strength **[carbon steel with corrosion-resistant coating][or][300 series stainless steel]**.
25. Nameplates:
- a. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
 - b. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
 - c. Locate nameplates in a highly visible location on motor side of fan.
 - d. Provide the following information on nameplate: **[Engraved][stamped][or][labeled]**.
 - 1) Manufacturer, address, phone number, and website address.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Manufacturing date.
 - 5) Fan size.
 - 6) Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).
 - 7) Design airflow.
 - 8) Design static pressure.
 - 9) Design fan speed.
 - 10) AMCA fan class.
 - 11) **<Insert requirement>**.
26. Air-Handling Unit Factory Assembly:
- a. Internal Access: Include each fan with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Removal and Replacement: Each fan wheel and motor shall be independently removable and replaceable through a removable access door installed in air-handling unit casing.
 - c. Stackable Fan Arrays: Construct frame work from aluminum[, **galvanized steel,**], **painted steel,**] or stainless steel.
 - d. Panel-Mounted Fan Array Supports:
 - 1) Construct a freestanding and self-supporting structural framework to support each

- fan individually from and independent of adjacent fans.
- 2) Construct frame work from aluminum[, **galvanized steel**],[, **painted steel**,] or stainless steel.

J. Centrifugal Plenum Fans:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Greenheck Fan Corporation]**
 - b. **[Loren Cook Company]**
 - c. **[New York Blower Company (The)]**
 - d. **[Twin City Fan & Blower]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Greenheck Fan Corporation]**
 - b. **[Loren Cook Company]**
 - c. **[New York Blower Company (The)]**
 - d. **[Twin City Fan & Blower]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain fans from single source from single manufacturer.
4. Operating Performance:
 - a. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - 1) Add additional static pressure to fan scheduled total static pressure.
 - 2) If fan motor horsepower is increased, notify Architect.
 - b. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.
 - c. Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.
 - d. Motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
 - e. Fan air performance ratings shall be based on tests in accordance with ASHRAE 51/AMCA 51 and AMCA 210.
 - f. Base fans sound ratings on AMCA 300 and calculation methods in accordance with AMCA 301.
 - g. At a minimum, fans shall have AMCA class indicated on Drawings.
 - 1) Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.
 - 2) If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - 3) AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.
 - h. Motor starting torque shall exceed fans speed-torque requirements.



5. Vibration Balance:
 - a. Each fan/motor assembly shall be factory balanced to AMCA 204, **[BV-5, Balance Quality Grade G1.0][BV-4, Balance Quality Grade G2.5][BV-3, Balance Quality Grade G6.3][Balance Quality Grade indicated on Drawings]**<Insert fan vibration balance requirements> or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be **[10][20]<Insert number>** percent of design speed.
 - b. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 - c. Submit test reports as an information submittal for Project record.
6. Operation and Service Requirements:
 - a. Each fan/motor assembly shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in air-handling unit.
 - b. Design and incorporate features to permit safe, rapid, and economical maintenance.
7. Fan Base:
 - a. Mount fan, motor, and drive on a structural-steel or an aluminum base; except, where indicated on Drawings, install fan on a concrete-filled inertia base.
 - b. Include base and vibration isolators in accordance with requirements indicated.
 - c. Electrically weld the base.
 - d. Size and design the base construction to withstand the rigors of shipping and rigging.
 - e. Include the base with lifting lugs or holes.
 - f. Construct base with gusseted brackets to accommodate spring isolators indicated.
8. Fan Panel:
 - a. Construct fan panel of aluminum or powder-coated steel.
 - b. Support fan wheel and bearings from a structural aluminum or powder-coated steel framework.
 - c. Reinforce and brace fan panel to prevent vibration and pulsation.
 - d. Include stiffeners to form a rigid panel that is free of structural resonance and vibration.
9. Fan Inlet and Wheel Cone:
 - a. Precision-spun or die-formed, matched inlet and wheel cone to ensure streamlined airflow into the wheel and full loading of blades.
 - b. Inlet and wheel cones shall be hyperbolic.
 - c. Inlet cone shall be a single piece, constructed of aluminum or powder-coated carbon steel.
 - d. Fasten inlet cone to fan panel using bolts, nuts and washers to provide a positive and secure attachment that can be field removable.
 - e. Inlet cones that are held in place using retaining clips are unacceptable.
10. Fan Wheel:
 - a. Fan blades shall be a true hollow airfoil shape, **[continuously]** welded to backplate and wheel cone.
 - b. Construct blades of aluminum, reinforced for AMCA fan class and operating conditions scheduled.
 - c. Design blades to provide smooth and aerodynamic airflow over all surfaces of blade.
 - d. Construct fan hubs of cast aluminum or cast-iron ASTM A48/A48M Class 20A and better, with integral bracing for extra strength and stiffness.

- 1) Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.
 - 2) Clean surfaces of castings by blasting, pickling, or other standard method.
 - 3) Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.
 - 4) Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.
 - e. Hubs shall be keyed and setscrewed to shaft for positive attachment.
 - f. Construct the wheel backplates of aluminum.
 - g. Statically and dynamically balance fan wheel before fan is assembled.
 - h. Select entire rotating assembly so first critical speed is at least **[30]<Insert number>** percent greater than fan design speed and at least **[20]<Insert number>** percent greater than maximum AMCA class speed.
11. Fan Drive:
- a. Direct drive, arrangement 4 in accordance with AMCA 99 for single-width, single-inlet fans.
 - b. Adjust wheel width and diameter to match motor speed while providing performance scheduled.
 - c. Fasten fan wheel directly to motor shaft using a key and setscrew as previously specified.
 - d. Construct motor base and pedestal of aluminum or powder-coated carbon steel plate.
 - e. Fan Speed Limitation: Fan speed at design conditions indicated shall not exceed speed on motor nameplate for direct-drive applications. Do not select fans to operate at motor speeds greater than motor nameplate.
12. Protective Screens: Factory furnish and install protective screens on fan inlet and discharge.
- a. **[Expanded metal][or][welded wire]** welded to a **[painted carbon steel][or][stainless steel]** frame.
 - b. Screens shall comply with OSHA requirements.
 - c. Screens shall be constructed of **[painted carbon][or][stainless]** steel.
 - d. Fasten screens to fan frame for easy removal by maintenance personnel.
13. Welding:
- a. Use AWS- or ASME-certified welders to weld materials required by application.
 - b. **[Where indicated on Drawings,][All]**welds shall be continuous full penetration welds.
14. Hardware: Hex-head, high-strength **[carbon steel][or][300 series stainless steel]**.
15. Nameplates:
- a. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
 - b. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
 - c. Locate nameplates in a highly visible location on motor side of fan.
 - d. Provide the following information on nameplate: **[Engraved][stamped][or][labeled]**.
 - 1) Manufacturer, address, phone number, and website address.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Manufacturing date.
 - 5) Fan size.
 - 6) Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).
 - 7) Design airflow.

- 8) Design static pressure.
- 9) Design fan speed.
- 10) AMCA fan class.
- 11) **<Insert requirement>**.

16. Air-Handling Unit Factory Assembly:

- a. Internal Access: Include each fan with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
- b. Removal and Replacement: Each fan shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
- c. Fan Supports:
 - 1) Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.
 - 2) Construct frame work from aluminum[, **galvanized steel,**][, **painted steel,**] or stainless steel.

K. Housed Centrifugal Fans:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Greenheck Fan Corporation]**
 - b. **[Howden American Fan Company]**
 - c. **[Loren Cook Company]**
 - d. **[New York Blower Company (The)]**
 - e. **[Twin City Fan & Blower]**
 - f. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Greenheck Fan Corporation]**
 - b. **[Howden American Fan Company]**
 - c. **[Loren Cook Company]**
 - d. **[New York Blower Company (The)]**
 - e. **[Twin City Fan & Blower]**
 - f. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain fans from single source from single manufacturer.
- 4. Operating Performance:
 - a. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - 1) Add additional static pressure to fan scheduled total static pressure.
 - 2) If fan motor horsepower is increased, notify Architect.
 - b. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.

- c. Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.
 - d. Motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
 - e. Fan air performance ratings shall be based on tests in accordance with ASHRAE 51/AMCA 51 and AMCA 210.
 - f. Base fans sound ratings on AMCA 300 and calculation methods in accordance with AMCA 301.
 - g. At a minimum, fans shall have AMCA class indicated on Drawings.
 - 1) Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.
 - 2) If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - 3) AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.
 - h. Motor starting torque shall exceed fan speed-torque requirements.
5. Vibration Balance:
- a. Each fan/motor assembly shall be factory balanced to AMCA 204, **[BV-5, Balance Quality Grade G1.0][BV-4, Balance Quality Grade G2.5][BV-3, Balance Quality Grade G6.3][Balance Quality Grade indicated on Drawings]<Insert fan vibration balance requirements>** or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be **[10][20]<Insert number>** percent of design speed.
 - b. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 - c. Submit test reports as an information submittal for Project record.
6. Operation and Service Requirements:
- a. Each fan/motor assembly shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in air-handling unit.
 - b. Design and incorporate features to permit safe, rapid, and economical maintenance.
7. Fan Base:
- a. Mount fan, motor, and drive assembly on an open structural base, except where Drawings indicate an inertia base.
 - b. Continuously weld base structural members constructed of **[aluminum][carbon steel][or][stainless steel]**.
 - c. **[Air-handling unit][or][fan]** manufacturer to size and design the fan base construction to withstand the rigors of shipping and rigging.
 - d. Fabricate base with lifting lugs or holes and gusseted brackets to accommodate spring isolators indicated.
8. Fan Housing:
- a. Continuously weld housing constructed of **[aluminum][carbon steel][or][stainless steel]** sheets, plates, and structural shapes.
 - b. Support fan housing and shaft bearings from a rigid structural framework.
 - c. Brace fan housing to prevent vibration and pulsation with external stiffeners to form a rigid housing that is free of operating resonance.
 - d. Extend fan housing side sheets not more than **[1/2 inch (13 mm)]<Insert dimension>** past fan scroll.
 - e. Fan Cut-off: Designed for pressure distribution required by the application.



- f. Fan Blast Area: At least **[80]<Insert number>** percent of fan outlet area.
 - g. Wheel Removal: Construct fan housing for fan wheel(s) removal through the inlet opening when the inlet cone is removed.
 - h. Split Housings: For fans with wheel diameters nominal **[49 inches (1225 mm)]<Insert dimension>** and larger, include diagonally flanged, gasketed and bolted split housings.
 - i. Access Doors: Quick-opening, gasketed, with heavy-duty latches.
 - 1) Conform to housing contour.
 - 2) Locate in 5 o'clock or 7 o'clock position about the end of the shaft and position to gain internal access.
 - 3) Maximize size of square access door up to **[24 inches (600 mm)]<Insert dimension>**.
 - j. Drains: **[NPS 1 (DN 25)]<Insert pipe size>** female NPT threaded half coupling welded to lowest point of fan housing. Position the drain connection to accommodate field-installed drain piping. Include each drain coupling with a stainless steel threaded plug.
 - k. Flanged Discharge Connections: Welded flanged discharge with a matching companion flange having evenly spaced holes for threaded hardware.
 - l. Flanged Inlet Connections: Welded flanged inlet with a matching companion flange having evenly spaced holes for threaded hardware.
9. Fan Inlet and Wheel Cones:
- a. Precision-spun or die-formed, matched inlet and wheel cones with hyperbolic shape to ensure streamlined airflow into the wheel and fully load the blades for efficient aerodynamic performance.
 - b. Inlet cone shall be a single piece, constructed of **[aluminum][carbon steel][or][stainless steel]**.
 - c. Fasten inlet cone to fan housing using bolts, nuts, and washers to provide a positive and secure attachment that can be removed and replaced in the field.
10. Fan Wheel:
- a. Fan blades with true hollow airfoil shape, continuously welded to backplate or centerplate and wheel cone(s).
 - b. Construct blades of **[aluminum][carbon steel][or][stainless steel]**, reinforced for AMCA fan class.
 - c. Design blades to provide smooth and aerodynamic airflow over all surfaces of blade.
 - d. Construct fan hubs of **[cast aluminum][cast iron, ASTM A48/A48M Class 20A and better][or][stainless steel]**, with integral bracing for extra strength and stiffness.
 - 1) Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.
 - 2) Clean surfaces of castings by blasting, pickling, or other standard method.
 - 3) Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.
 - 4) Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.
 - e. Key and setscrew hubs to shaft for positive attachment.
 - f. Construct wheel backplates or centerplates of **[aluminum][carbon steel][or][stainless steel]**.
 - g. Statically and dynamically balance fan wheel before fan is assembled.
 - h. Select entire rotating assembly so first critical speed is at least **[30]<Insert number>** percent greater than fan design speed and at least **[20]<Insert number>** percent greater

than maximum AMCA class speed.

11. Fan Shafts:

- a. Fan shaft shall be one piece, solid **[carbon][or][stainless]** steel, accurately turned, ground, polished, and inspected.
- b. Polish shafts at the point of bearing contact to comply with bearing manufacturer's recommended tolerances.
- c. Inspect shafts for straightness after the keyways are cut.
- d. Coat carbon steel shafts with a rust-inhibitive coating.

12. Fan Shaft Bearings:

- a. Fan bearings shall be foot-mounted type, bolted on a rigid welded steel framework that is integral with, or independent of, the housing.
- b. Size bearings for L-10 life of at least **[200,000]<Insert value>** hours, a DN factor less than **[200,000]<Insert value>** and a load factor less than **[2,700,000]<Insert value>** at the maximum fan class load limit horsepower, including belt pull.
- c. Select bearings in accordance with **[ABMA 9][and][or][ABMA 11]**.
- d. Types:
 - 1) Bearings for Fans with Motor Horsepower up to 10 hp (7.5 kW): Single-row ball or spherical bearings, self-aligning, grease lubricated, and housed in a pillow block housing.
 - 2) Bearings for Larger-Size Fans: Double-row spherical, self-aligning, grease lubricated, and housed in a horizontally split pillow block housing.
- e. Grease Fittings:
 - 1) Extend **[copper][or][plastic]** grease lines to an accessible location within sight of bearing for greasing the bearings without removing guards, inlet screens, linkages, and other appurtenances.
 - 2) Terminate bearings and extended grease lines with grease gun fittings.

13. Fan Drives: Fan-drive type, belt or direct, as indicated on Drawings.

a. Direct Drives:

- 1) Double Width, Double Inlet: Arrangement 7 in accordance with AMCA 99.
- 2) Single Width, Single Inlet: Arrangement **[4][or][5]** in accordance with AMCA 99.
- 3) For AMCA arrangements 4 and 5, fasten fan wheel directly to motor shaft using a key and setscrew indicated.
- 4) Construct motor base and pedestal for AMCA arrangement 4 and 7 fans of **[aluminum][carbon steel][stainless steel]** plate.

b. Belt Drives:

- 1) Multiple V-Belt Design:
 - a) Size two belt drives for at least **[2.0]<Insert value>** times the fan motor horsepower.
 - b) Size belt drives with more than two belts, for at least **[1.5]<Insert value>** times the fan motor horsepower.
 - c) Coordinate, with motor manufacturer, the size and location of motor sheave required to satisfy the motor L-10 bearing life using motor manufacturer's written instructions.

- d) Sheave and V-belt selections shall be in accordance with manufacturer's published data.
- 2) Sheaves:
 - a) Constant-Speed Applications: Fixed or variable sheaves for applications up to **[5 hp (4 kW)]<Insert size>** and fixed sheaves for applications with larger horsepower.
 - b) Variable-Speed Applications: Fixed sheaves.
 - c) Profile machined to Mechanical Power Transmission Association Standards.
 - d) Construct sheaves of high-strength cast iron having a minimum tensile strength of **[25,000 psi (172.4 MPa)]<Insert value>**.
 - e) Sheave rim speeds shall not exceed **[5000 fpm (25.4 m/s)]<Insert value>**.
 - f) Sheave side wobble and runout, and eccentricity shall be within Mechanical Power Transmission Association and Rubber Manufacturers Association (RMA) tolerances.
 - g) Balance sheaves to satisfy vibration performance requirements.
 - h) Mount sheaves on the shaft using a taperlock split and keyed bushing or an integral keyed bushing.
- 3) V-Belts:
 - a) V-belts shall be oil resistant, non-static conducting, and high quality in accordance with RMA standards.
 - b) Classic A, B, C, D, and E, non-cogged, cross sections.
 - c) Multiple belt drives shall be a matched set with belt tolerances in accordance with RMA standards.
 - d) Tension belts in accordance with manufacturer's written instructions.
- c. Drive Guards: Furnish and factory install fan drive guard(s) for bearing assemblies, rotating shafts, sheaves, belts, couplings, and heat slingers.
 - 1) Arrangement 3 fans do not require guards for bearings on the side opposite the drive.
 - 2) Make provision for motor and fan rpm measurement without removing the guard.
 - 3) Construct the guard of flattened expanded aluminum or steel wrapped around a channel frame, suitably braced to prevent vibration.
 - 4) Paint guards using the same coating as fan, except color shall be safety yellow.
 - 5) Design attachment to fan for easy removal by maintenance personnel using a clamp and latch.
- 14. Discharge Damper, Counterbalanced Backdraft:
- 15. Performance:
 - a. Velocity and Pressure Rating: Suitable for a face velocity of up to **[4000 fpm (20 m/s)]<Insert value>** and a static pressure differential of **[8.0 inches wg (2000 Pa)]<Insert value>**.
 - b. Leakage: Not to exceed **[15 cfm/sq. ft. (0.66 L/s per sq. m)]<Insert value>** at a static pressure differential of **[1.0 inch wg (250 Pa)]<Insert value>**.
- 16. Construction:
 - a. Frame: Minimum **[10-gauge- (3.6-mm-)]<Insert thickness>** thick, **[galvanized-steel][or][stainless steel]** channel frame. Frame to extend beyond blade in open position.
 - b. Blades: Double-skin airfoil-type parallel blades, constructed of minimum **[18-gauge- (1.3-**

- mm-)]<Insert thickness> thick, [galvanized][or][stainless] steel. Include dividers and bracing to form a rigid framework.
- c. Axles: [Steel][or][stainless steel]; full length of blade and supported by lubricated ball bearings.
17. Mounting:
- a. Mount blade axle linkage [in][or][out] of airstream.
18. Seals:
- a. Blades: EPDM.
- b. Jams: Stainless steel, compression-type seals.
19. Discharge Damper, Motorized: Where indicated on Drawings, furnish fans with factory-installed automatic dampers assembled complete in all respects to functions intended.
- a. Performance:
- 1) Velocity and Pressure Rating: Suitable for a face velocity of at least [5000 fpm (25.4 m/s)]<Insert value> and a static pressure differential of [8.5 inches wg (2125 Pa)]<Insert value>.
 - 2) Leakage: Not to exceed [8 cfm/sq. ft. (0.35 L/s per sq. m)]<Insert value> at a static pressure differential of [4.0 inches wg (1000 Pa)]<Insert value>.
- b. Construction:
- 1) Frame: Minimum [10-gauge- (3.6-mm-)]<Insert thickness> thick, [galvanized-steel][or][stainless steel] channel frame. Frame to extend beyond blade in open position.
 - 2) Blades: Double-skin airfoil-type parallel blades, constructed of minimum [14-gauge- (2.0-mm-)]<Insert thickness> thick, [galvanized][or][stainless] steel. Include dividers and bracing to form a rigid framework.
 - 3) Axles: Each blade with full length axle supported by lubricated ball bearings. Include thrust bearings for dampers mounted in the vertical orientation.
- c. Mounting:
- 1) Mount blade axle linkage out of airstream.
 - 2) Mount damper to fan discharge so damper blades are perpendicular to fan shaft.
 - 3) Configure linkage assembly to interface with single electric actuator.
- d. Seals:
- 1) Blades: EPDM.
 - 2) Jams: Stainless steel, compression-type, double seals. Jamb seal shall use an outer standard width seal and a narrow inner seal for maximum compression and minimum leakage when blade is in closed position.
- e. Damper Electric Actuator:
- 1) Furnish and factory install an electric actuator for each automated fan discharge damper.
 - 2) Mount actuator on damper frame.
 - 3) Construct interconnecting linkages, lever, and brackets of [aluminum][carbon steel][or][stainless steel]. Paint interconnecting linkages, lever, and brackets to

- match the fan coating.
 - 4) Action, either modulating or two position, as indicated on Drawings.
 - 5) Fail-safe operation (open, closed, or last position) as indicated on Drawings.
 - 6) Size actuators to do the following:
 - a) Shut off against fan maximum pressure on fan curve at design speed.
 - b) Operate the damper with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which damper is subjected.
 - 7) Actuator to include the following:
 - a) Indicator and graduated scale on each actuator to show open and closed positions at travel limits.
 - b) Adjustable stops for both maximum and minimum positions.
 - 8) Coordinate control interface requirements with external controls to comply with operation indicated.
20. Shaft Seals:
- a. Provide single-width, single-inlet fans with shaft seal(s) where indicated on Drawings.
 - b. Shaft seal(s) shall minimize fan leakage when operating and not operating.
 - c. Construct shaft seal of an aluminum or split stainless steel plate with non-asbestos material fitted under the split metal plate and seated around the shaft.
 - d. Secure split plates to housing using threaded hex-head hardware.
 - e. Shaft seals shall be replaceable from outside the housing without disturbing the shaft or bearings.
 - f. Select shaft seal clearances and materials for operating temperature, pressure, and air quality encountered.
 - g. Shaft seals, including labyrinth, floating bushing, or close clearance annulus, are acceptable alternatives.
21. Protective Screens: Factory furnish and install safety screens on unducted fan inlets and discharge openings.
- a. **[Expanded metal][or][welded wire]** welded to a **[painted carbon steel][or][stainless steel]** frame.
 - b. Screens shall comply with OSHA requirements.
 - c. Screens shall be constructed of **[painted carbon steel][or][stainless steel]**.
 - d. Fasten screens to fan for easy removal by maintenance personnel.
22. Piezometer Ring: Mount at fan inlet cone for airflow measurement.
23. Welding:
- a. Use AWS- or ASME-certified welders to weld materials required by application.
 - b. **[Where indicated on Drawings,][All]**welds shall be continuous full-penetration welds.
24. Hardware: Hex-head, high-strength **[carbon steel][or][Type 304 or Type 316 stainless steel]**.
25. Nameplates:
- a. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
 - b. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
 - c. Locate nameplates in a highly visible location on motor side of fan.

- d. Provide the following information on nameplate: **[Engraved][stamped][or][labeled]**.
- 1) Manufacturer, address, phone number, and website address.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Manufacturing date.
 - 5) Fan size.
 - 6) Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).
 - 7) Design airflow.
 - 8) Design static pressure.
 - 9) Design fan speed.
 - 10) AMCA fan class.
 - 11) **<Insert requirement>**.
26. Special Fan Construction: Where indicated on Drawings, construct individual fans with the following additional features.
- a. Spark-Resistant Construction: Construct fans in accordance with AMCA 99 **[Type A][Type B][Type C]** spark-resistant construction **[where indicated on Drawings]**.
- b. Heat Slinger: Provide for fans handling air with temperatures exceeding **[150 deg F (65 deg C)]<Insert temperature>**.
- 1) Cast aluminum, split-design, internally-finned rotor to create a strong circulation of air over the shaft and inboard bearing, and reduce heat conduction along the shaft to bearings.
 - 2) Secure the split halves together using at least two stainless steel bolts and use a setscrew to secure the assembly to fan shaft.
- c. Corrosion-Resistant Coating:
- 1) Baked phenolic, **[equal to Heresite's "P-4403 Brown Baked Phenolic Coating."]<Insert manufacturer's name and product name or designation.>**
 - 2) Total Dry Film Thickness: **[7]<Insert value>** mils.
 - 3) Application in accordance with manufacturer's written instructions and the following:
 - a) Mist bonding pass and allow to flash off for several minutes, but not long enough to allow film to completely dry.
 - b) Not less than three crisscross multipasses maintaining a wet-appearing film.
 - c) Air dry approximately 45 to 60 minutes with ventilation before applying heat.
 - d) After air dry period has elapsed, raise temperature in recommended increments of 30 minutes until desired temperature is reached.
 - e) Bake intermediate coats at approximately half the final temperature for 10 to 20 minutes.
 - f) Final Bake: **[400 deg F (205 deg C)]<Insert temperature>** for 1-1/2 hours.
- d. **<Insert requirements>**.
27. Air-Handling Unit Factory Assembly:
- a. Internal Access: Include each fan with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Removal and Replacement: Each fan shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - c. Fan Supports:

- 1) Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.
- 2) Construct frame work from aluminum[, **galvanized steel**][, **painted steel**,] or stainless steel.

L. Fan Motors:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Baldor Electric Company]**
 - b. **[Emerson Electric Company]**
 - c. **[Regal Beloit (Genteq)]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **[Toshiba International Corporation]**
 - f. **[US Motors; Nidec Motor Corporation; Nidec Corporation]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Baldor Electric Company]**
 - b. **[Emerson Electric Company]**
 - c. **[Regal Beloit (Genteq)]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **[Toshiba International Corporation]**
 - f. **[US Motors; Nidec Motor Corporation; Nidec Corporation]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain motors from single source from single manufacturer.
4. Standard: Comply with NEMA MG 1 unless more stringent requirements are indicated.
5. Description: NEMA MG 1, **[Design B]<Insert design>**, as required to comply with capacity and torque characteristics; medium-induction motor.
 - a. Performance:
 - 1) Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
 - 2) Efficiency: NEMA Premium Efficiency rating complying with NEMA MG 1.
 - 3) Motor Horsepower: Minimum size as indicated on Drawings. Motor shall operate fan under all conditions indicated without exceeding motor nameplate and without use of motor service factor.
 - 4) Inverter-Duty Rating: Comply with minimum requirements of Class F or Class H insulation, suitable for "inverter-duty" or "drive-duty" applications in accordance with NEMA MG 1. Motor operation through a variable-frequency controller shall not adversely affect the motor performance, operation, useful life, and warranty.
 - 5) Service Factor: **[1.15]<Insert value>**.
 - 6) Temperature Rise: **[Match][One class lower than]<Insert requirements>** insulation rating.

6. Enclosure Type: **[See Drawings for motor enclosure type][ODP][or][TEFC]**.
7. Shaft Grounding System:
 - a. Shaft grounding system to protect bearings from induced voltage.
 - b. Shaft grounding system shall have low drag (less than 0.05 percent of motor horsepower), and shall operate for a minimum of three years without periodic maintenance or adjustments.
 - c. Mounting: External **[or internal]**to motor enclosure.
8. Frame:
 - a. Frames with integrally cast feet unless other requirements of driven equipment require a different arrangement.
 - b. Frame, front and back end brackets, and front and back end bearing intercaps constructed of cast iron, ASTM A48/A48M, Class 25 or better.
9. Rotor:
 - a. Fabricate rotor frame from die-cast aluminum, copper, or associated alloys.
 - b. Key rotors to motor shaft.
 - c. Rotating assembly shall be dynamically balanced to within limits defined in NEMA MG 1.
 - d. Motors shall have the entire rotating assembly between bearing inner caps coated with a corrosion-resistant coating.
10. Stator:
 - a. Copper windings shall be spike resistant to withstand 1600 peak V.
 - b. Entire wound and insulated stator coated with a coating to protect against moisture and corrosion.
11. Shaft:
 - a. Solid shaft fabricated of **[carbon][Type 304 stainless][Type 316 stainless][Type 416 stainless]** steel, accurately turned, ground and polished, and inspected for accuracy.
 - b. End of shaft with drilled hole for use in field measurements.
12. Bearings:
 - a. Grease-lubricated ball or roller bearings.
 - b. ABMA 11 L-10 motor bearing life of **[100,000]<Insert value>** hours.
 - c. Bearing Lubrication:
 - 1) Factory lubricate motor bearings using a premium moisture-resistant polyurea thickened grease with rust inhibitors suitable for extreme operating temperatures encountered.
 - 2) Coordinate special requirements that may impact lubrication and include appropriate lubrication.
13. Grease Fittings:
 - a. Equip each bearing housing with an easily accessible grease inlet.
 - b. Fit grease inlets with a grease fitting and protective fitting cap.
 - c. Equip inlets with an automatic grease relief fitting to prevent excessive greasing.
 - d. Equip each bearing housing with grease drain and threaded plug.
14. Conduit Box:



- a. Material same as frame.
 - b. For motor frames 365T and below, furnish conduit boxes sized with internal volumes in accordance with NEMA MG 1.
 - c. For motor frames larger than 365T, furnish conduit boxes one size larger than NEMA MG 1.
 - d. Coordinate the location and mounting of conduit box with driven equipment manufacturer.
 - e. Factory mount conduit box on motor.
15. Grounding: NRTL-listed clamp-type grounding lug mounted in conduit box.
16. Motor Leads:
- a. Non-wicking type, Class F temperature rating or better and permanently numbered over entire length for identification.
 - b. Lead terminals shall be manufacturer's standard.
17. Condensate Drains:
- a. Motor with drain holes at the lowest point for drainage of condensate.
 - b. Each drain hole with a threaded removable plug.
18. TEFC Motor Fans: Corrosion-resistant construction, non-sparking, metallic or non-metallic, bi-directional, and keyed to shaft.
- a. Motor Fan Cover: **[Steel][Same material as frame]**.
19. Hardware: Hex-head, high-strength, zinc-plated carbon steel or stainless steel.
20. Lifting Eyebolts: Eyebolt threaded into frame receptacle and design to prevent moisture and other foreign material from entering motor cavity when eyebolt is removed.
21. Nameplates:
- a. Construct nameplates of aluminum or stainless steel and attach to motor frame with aluminum, stainless steel, or brass drive pins.
 - b. Engrave or stamp data on the nameplate.
 - c. At a minimum, include nameplate data in accordance with NEMA MG 1. **[Also include ABMA bearing designation for the drive and opposite end bearing.]**
22. Paint: Successfully pass **[500][1000][2000]<Insert value>**-hour salt spray test for corrosion in accordance with ASTM B117.

M. Vibration Isolation:

1. General:
- a. Provide fans inside air-handling units with base and vibration isolation indicated on Drawings.
2. Inertia Bases:
- a. Description: Reinforced structural base designed for concrete infill with integral bolting provisions for fan mounting.
 - b. Design and Performance:
 - 1) Weight of inertia base including concrete infill a minimum of 1.5 times the operating weight of fan.
 - 2) Base thickness not less than 1/12 of longest span.

- 3) Minimum base thickness is as follows:
 - a) Up to 15 HP (11 kW): **[6 inches (150 mm)]<Insert thickness>**.
 - b) 20 to 50 HP (15 to 37 kW): **[8 inches (200 mm)]<Insert thickness>**.
 - c) 60 to 75 HP (45 to 56 kW): **[10 inches (250 mm)]<Insert thickness>**.
 - d) 100 HP (75 kW) and Larger: **[12 inches (300 mm)]<Insert thickness>**.
- c. Construction:
 - 1) Base Materials: **[Structural carbon steel, ASTM A36/A36M][structural stainless steel, ASTM A276/A276M, Type 304L][or][structural stainless steel, ASTM A276/A276M, Type 316L]**.
 - a) Carbon Steel Finish, Mill Galvanized: Mill-galvanized carbon steel bases with weld-damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.
 - b) Carbon Steel Base Finish: Carbon steel bases cleaned in accordance with SSPC SP-1, **[SSPC SP-6/NACE No. 3][SSPC SP-10/NACE No. 5]** and **[painted][or][hot-dip galvanized]** after fabrication.
 - 2) Base Structural Members:
 - a) Perimeter Members: **[Channel][I or W beam shapes][or][tube]**.
 - b) Intermediate Members (Spanning Full-Width Base): **[Channel][or][I or W beam shapes][or][tube]**.
 - c) Cross Members (Spanning Intermediate Members): **[Angle][channel][or][tube]**.
 - 3) Reinforcing Bars: Carbon steel, ASTM A615/A615M, sized for a maximum stress of **20,000 psi (138 000 kPa)** when subjected to both static and dynamic loads, and welded in place.
 - 4) Floor: Design inertia base with solid floor in bottom for concrete placement after base installation. Seal to prevent leakage or seepage.
 - a) Galvanized-Steel Solid Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating, minimum (nominal) **[18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value>** thick.
 - b) Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M; **[Type 304][Type 304L][Type 316][Type 316L]<Insert type>**; No. **[2D][4]<Insert finish>** finish; minimum (nominal) **[18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value>** thick.
 - 5) Isolator Brackets: Gusseted, height-saving brackets.
 - 6) Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
- d. Air-Handling Unit Factory Assembly: Install fans with inertia bases where indicated on Drawings.
 - 1) Coordinate placement of inertia bases with design of air-handling unit structural base. Make provisions for attachment and support.
 - 2) Coordinate inertia base mounting provisions with spring isolators.

3. Spring Isolators:

a. Performance:

- 1) Deflection: Minimum deflection indicated on Drawings. Use a greater deflection if required to maintain an isolator efficiency of at least **[98]<Insert number>** percent under all operating conditions encountered. Calculate isolator efficiency using actual support conditions considering the rigidity of structure.
 - 2) Laterally stable freestanding open-spring mounting.
 - 3) Spring diameter not less than 0.8 of compressed spring height at rated load and in the installed and operating condition.
 - 4) Reserve travel to solid shall be equal to a minimum of 50 percent of rated deflection and in no case less than 25 percent of rated deflection in an installed and operating condition.
 - 5) Ratio of horizontal stiffness to vertical stiffness equal to approximately one.
 - 6) Design and install so that ends of springs remain parallel.
 - 7) Select springs that are non-resonant with equipment related frequencies and natural frequencies of support structure.
 - 8) Springs shall not take a permanent set when compressed to coil bind.
 - 9) Seismic restraints to limit motion under seismic forces to **[1/4 inch (6 mm)]<Insert dimension>**.
- b. Construction:
- 1) Coat springs with PVC or neoprene. Color-code springs to allow positive identification after installation.
 - 2) Construct baseplates, spring retainers, and other components of **[aluminum][galvanized carbon steel][or][stainless steel]**. Etch and paint aluminum components.
 - 3) Use nuts, bolts, and washers and other associated hardware constructed of **[zinc-electroplated carbon steel][or][stainless steel]**.
 - 4) Isolators with integral leveling bolts.
 - 5) Baseplates with holes and isolation grommets for bolting.
 - 6) Bond nominal **[1/4-inch- (6-mm-)]<Insert dimension>** thick, neoprene friction pad to baseplate.
4. Thrust Restraints:
- a. In sets of two or more, thrust restraints shall consist of springs in series with neoprene isolators.
 - b. Coordinate and select deflection of thrust restrains with equipment being restrained.
 - c. Thrust restraints complete with rods and adjustment nuts, plus angle brackets and backing plates for attachment to substrate and equipment being restrained.
5. Elastomeric Grommets:
- a. Elastomeric grommets shall be a combination of neoprene washer and bushing.
 - b. Elastomer shall be 56-durometer maximum.
 - c. Grommets formed to prevent bolts from directly contacting the secured item.
6. Flexible Connections:
- a. Construct flexible connection **[galvanized-steel][or][stainless steel]** edges firmly attached to waterproof and fire-retardant fabric.
 - b. Fabric shall be **[6 inches (150 mm)]<Insert dimension>** wide or more.
 - c. Suitable for operation in extreme temperatures encountered.
 - d. NRTL listed for application and complying with NFPA 90A.
7. Air-Handling Unit Factory Assembly:

- a. Use precompression -type height-saving brackets with isolators having [2-1/2 inch (65-mm)]<Insert dimension> deflection or greater, to limit exposed bolt length.
- b. Install spring isolators plumb and adjust isolators that are not plumb under operating conditions to make plumb.
- c. Adjust isolators to prevent stress transfer to equipment.
- d. Verify that installed isolators and mounting systems permit equipment motion in all directions.
- e. Restraint fans with isolated thrust resistors to limit displacement to [1/4 inch (6 mm)]<Insert dimension>. Design for the maximum lateral thrust the fan can develop.
- f. Adjust or include additional resilient restraints to flexibly limit fan lateral motion to [1/4 inch (6 mm)]<Insert dimension> during startup and operation of equipment.
- g. Anchor restraints to fixed supports having a stiffness greater than the thrust encountered.
- h. Include at least [2-inch (50-mm)]<Insert dimension> operating clearance between fan bases and walking surface of air-handling unit floor. Before startup, clean out foreign matter between bases and equipment to prevent short circuit.
- i. Flexible Connections:
 - 1) Install flexible connections at connections to fans.
 - 2) Install flexible connections in accordance with SMACNA standards and manufacturer's written instructions.
 - 3) Make fabric joints on the flat run, not the corners, with overlap to provide an area sufficient to make a positive seal.
 - 4) Apply adhesive between fabric layers.
 - 5) Attach connections using screws or bolts.
 - 6) Reinforce fabric if required to keep fabric from collapsing and impacting airflow into fan.

N. Hydronic Coils:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Aerofin]
 - b. [Coilmaster Corporation]
 - c. [Modine Manufacturing Company]
 - d. [Super Radiator Coils]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Aerofin]
 - b. [Coilmaster Corporation]
 - c. [Modine Manufacturing Company]
 - d. [Super Radiator Coils]
 - e. <Insert manufacturer's name>
3. Sourcing Option: In lieu of sourcing hydronic coils from a specialty coil manufacturer, air-handling unit manufacturer has option to furnish in-house hydronic coils that achieve equal or better performance while complying with other requirements indicated.
4. General: Provide air-handling units with hydronic coils where indicated on Drawings.
5. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die formed into plate fins.

6. Design and Performance:
- a. Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.
 - b. Air pressure drop, water pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.
 - c. Coils shall be counterflow design, air to fluid. Fluid supply shall enter air leaving side of coil and exit air entering side.
 - d. Design coils to be drainable.
 - 1) Coils shall have all circuits drainable when coils are installed in horizontal position and level.
 - 2) Coil supply **[and return]**header shall be furnished with a drain connection at lowest point on header.
 - e. Design coils to be self-venting.
 - 1) Supply connection near bottom of supply header.
 - 2) Return connection near top of return header.
 - 3) Furnish coil return **[and supply]**header with a vent connection at highest point on header.
 - f. Coils supply and return piping connections on same end of coil.
 - g. Coils shall be rated for system operating pressures and temperatures encountered by installation, but not less than **[200 psig (1379 kPa)][300 psig (2069 kPa)]<Insert pressure>**.
 - h. Coil selection criteria, unless otherwise indicated on Drawings, are as follows:
 - 1) Face Velocity: Maximum of **[500 fpm (2.5 m/s)]<Insert value>**.
 - 2) Fluid Tube Velocity (at Design Flow Rate):
 - a) Maximum: **[6 fps (1.8 m/s)]<Insert velocity>**.
 - b) Minimum: **[3 fps (0.9 m/s)]<Insert velocity>**.
 - 3) Fluid Header Velocity: Maximum of **[6 fps (1.8 m/s)]<Insert velocity>**.
 - a) Fin Height: Maximum of **[48 inches (1200 mm)]<Insert dimension>**.
 - b) Fin Spacing: Maximum of **[12 fins per inch (2.1 mm)]<Insert spacing>**.
 - i. Cooling coils shall have no moisture carryover at design conditions. Install moisture eliminators on discharge face of coil if it is necessary to eliminate moisture carryover.
7. Casing and Tube Sheets:
- a. Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch (13 mm)]<Insert dimension>** beyond face of fins on both entering and leaving side.
 - b. Casing and Tube Sheet Materials:
 - 1) Cooling Coils: Stainless steel, ASTM A240/A240M or ASTM A480/A480M, **[Type 304L][or][Type 316L]**, No. 2D finish.
 - 2) Heating Coils:
 - a) Stainless steel, ASTM A240/A240M or ASTM A480/A480M, **[Type 304L][or][Type 316L]**, No. 2D finish.
 - b) Galvanized steel, ASTM A653/A653M, **G90 (Z275)** coating.

- c. Top and Bottom Casings:
 - 1) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>; double flange edge for rigidity and ease of removal with secondary flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
 - 2) Thickness:
 - a) Coils with Fin Length of up to [72 Inches (1800 mm)]<Insert dimension>: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - b) Coils with Fin Length Exceeding [72 Inches (1800 mm)]<Insert dimension>: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - d. End Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>.
 - 3) Thickness: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - e. Intermediate Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Space intermediate tube sheets a maximum of [48 inches (1200 mm)]<Insert dimension> o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 - 3) Flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
 - 4) Thickness: Minimum of [16 gauge (1.6 mm)]<Insert thickness> thick.
 - f. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.
8. Fins:
- a. Materials:
 - 1) Aluminum: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 2) Copper: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 3) 90/10 Cupronickel: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - b. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 - c. Fin Configuration: [Flat face fins without ripples][Flat face or enhanced ripple fins as required by performance].
9. Headers:
- a. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.

- b. Tube-to Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness, to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than **0.12 inch (3 mm)**.
 - c. Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.
 - d. Drains: Include low point of **[supply][supply and return]** header with a **[NPS 1/2 (DN 13)]<Insert pipe size>** drain connection. Extend copper or **[red brass][carbon steel][stainless steel]<Insert material>** pipe through air-handling unit casing and terminate end with male national pipe threads (MNPT). Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - e. Vents: Include high point of **[return][supply and return]** header with a **[NPS 1/2 (DN 13)]<Insert pipe size>** vent connection. Extend copper or **[red brass][carbon steel][stainless steel]<Insert material>** pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - f. Supply and Return Connections:
 - 1) Terminate ends with MNPT.
 - 2) Connections to header shall be either copper tube with brazed ASME B16.18 threaded male adapters or **[red brass][carbon steel][stainless steel]<Insert material>** pipe with machine-threaded MNPT connections. Pipe shall extend through air-handling unit casing and be threaded on both ends to facilitate easy field removal and replacement.
 - 3) Connections **[NPS 2-1/2 (DN 65)]<Insert pipe size>** and larger shall have a bronze ASME 16.24 threaded flanges attached to threaded connections to provide for a flanged field connection. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
 - g. Protect openings of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into the coil.
10. Tubes:
- a. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper; **[90/10 cupronickel alloy, ASTM B122/B122M]**.
 - b. Tube Nominal Diameter: **1/2 or 5/8 inch (13 or 16 mm)** before expanding, selected to provide performance indicated.
 - c. Tube Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch (0.5 mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension>** thick.
11. Tube Return Bends: 180-degree bends brazed to tubes; material[, **wall thickness,**] and nominal diameter to match tubes.
- a. Tube Return Bend Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch (0.5 mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension>** thick.
12. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.
13. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
14. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:

- a. Baked phenolic.
 - b. Cathodic epoxy.
 - c. Water-based flexible epoxy polymer.
 - d. Water-based synthetic flexible polymer.
 - e. **<Insert coating type>**.
15. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304][or][Type 316]** stainless steel.
 16. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. Coil fin length.
 - g. Coil fin height.
 - h. Coil weight with fluid/without fluid.
 - i. Coil casing material and thickness.
 - j. Coil fin material and thickness.
 - k. Coil tube material and thickness.
 - l. Coil header material and thickness.
 - m. **<Insert requirements>**.
 17. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
 18. Air-Handling Unit Factory Assembly:
 - a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches (100 mm)]<Insert dimension>** beyond exterior face of access panel, and seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Include each coil with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct framework for cooling coils, from aluminum or stainless steel **[structural shapes]**.
 - 3) Construct frame work for heating coils from aluminum[, **galvanized steel,**] or stainless steel **[structural shapes]**.

O. Refrigerant Coils:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Aerofin]**
 - b. **[Coilmaster Corporation]**

- c. **[Modine Manufacturing Company]**
 - d. **[Super Radiator Coils]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aerofin]**
 - b. **[Coilmaster Corporation]**
 - c. **[Modine Manufacturing Company]**
 - d. **[Super Radiator Coils]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain coils from single source from single manufacturer.
4. General: Provide air-handling units with refrigerant coils where indicated on Drawings.
5. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die formed into plate fins. Coils shall be counterflow circuited and equipped with pressure-type distributors. Distributor tubes shall be of equal length to ensure equal distribution of refrigerant to each circuit.
6. Circuiting: **[Face][Row][Interlaced][Interlaced and face control][Indicated on Drawings]<Insert circuiting type>**.
7. Performance:
 - a. Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.
 - b. Air pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.
 - c. Rate coils in accordance with AHRI 410 when tested in accordance with ASHRAE 33.
 - d. Coil performance variables and selection procedures shall be in accordance with AHRI 410.
 - e. Coils piping connections on same end of coil.
 - f. Coils shall be rated for system operating flows, pressures, and temperatures encountered by installation.
 - g. Coil selection criteria, unless otherwise indicated on Drawings, are as follows:
 - 1) Face Velocity: Maximum of **[500 fpm (2.5 m/s)]<Insert value>**.
 - 2) Fin Height: Maximum of **[48 inches (1200 mm)]<Insert dimension>**.
 - 3) Fin Spacing: Maximum of **[12 fins per inch (2.1 mm)]<Insert spacing>**.
 - h. Cooling coils shall have no moisture carryover at design conditions. Install moisture eliminators on discharge face of coil if it is necessary to eliminate moisture carryover.
8. Casing and Tube Sheets:
 - a. Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch (13 mm)]<Insert dimension>** beyond face of fins on both entering and leaving side.
 - b. Casing and Tube Sheet Materials: Stainless steel, ASTM A240/A240M or ASTM A480/A480M, **[Type 304L][or][Type 316L]**, No. 2D finish.
 - c. Top and Bottom Casings:
 - 1) Flange face minimum of **[1-1/2 inches (68 mm)]<Insert dimension>**; double flange edge for rigidity and ease of removal with secondary flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
 - 2) Thickness: Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8**

mm)] thick.

d. End Tube Sheets:

- 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
- 2) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>.
- 3) Thickness: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.

e. Intermediate Tube Sheets:

- 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
- 2) Space intermediate tube sheets a maximum of [48 inches (1200 mm)]<Insert dimension> o.c. and locate to provide equal spacing between tube sheet across coil tube length.
- 3) Flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
- 4) Thickness: Minimum of [16 gauge (1.6 mm)]<Insert thickness> thick.

f. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

9. Fins:

- a. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
- b. Configuration: [Flat face fins without ripples][Flat face or enhanced ripple fins as required by performance].
- c. Materials:
 - 1) Aluminum: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 2) Copper: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 3) 90/10 Cupronickel: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.

10. Headers:

- a. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.
- b. Tube-to Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than 0.12 inch (3 mm).
- c. Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.
- d. Protect openings to prevent entry of dirt into the coil.

11. Tubes:

- a. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper.
- b. Tube Nominal Diameter: Selected for performance indicated.
- c. Tube Nominal Wall Thickness: As required by performance, minimum of [0.020 inch (0.5

mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension> thick.

12. Tube Return Bends: 180-degree bends brazed to tubes; material, wall thickness, and nominal diameter to match tubes.
13. Brazing: High-temperature brazing alloy with not less than 5 percent silver.
14. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
15. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:
 - a. Baked phenolic.
 - b. Cathodic epoxy.
 - c. Water-based flexible epoxy polymer.
 - d. Water-based synthetic flexible polymer.
 - e. <Insert coating type>.
16. Hardware: Use hex-head bolts, nuts, and washers constructed of [Type 304][or][Type 316] stainless steel.
17. Nameplates: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. Coil fin length.
 - g. Coil fin height.
 - h. Coil weight.
 - i. Coil casing material and thickness.
 - j. Coil fin material and thickness.
 - k. Coil tube material and thickness.
 - l. Coil header material and thickness.
 - m. <Insert requirements>.
18. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
19. Air-Handling Unit Factory Assembly:
 - a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately [4 inches (100 mm)]<Insert distance> beyond exterior face of the access panel, and seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Provide each coil with internal access from [downstream][and][upstream] sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct framework for cooling from aluminum or stainless steel[structural shapes].

P. Steam Coils:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Aerofin]**
 - b. **[Coilmaster Corporation]**
 - c. **[Modine Manufacturing Company]**
 - d. **[Super Radiator Coils]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aerofin]**
 - b. **[Coilmaster Corporation]**
 - c. **[Modine Manufacturing Company]**
 - d. **[Super Radiator Coils]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain coils from single source from single manufacturer.
4. General: Provide air-handling units with refrigerant coils where indicated on Drawings.
5. Description: Plate fin coils constructed of tubes mechanically expanded into continuous collars that are die formed into plate fins and specially designed for thermal expansion and contraction of the tubes during coil operation.
 - a. Distributing-type steam coils of a tube-in-tube design for uniform steam distribution along the entire length of each tube to ensure a consistent temperature rise across the full coil face and accelerate condensate removal.
 - b. Non-distributing-type steam coils of a single tube design for uniform steam distribution across the entire header and each tube.
6. Design and Performance:
 - a. Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.
 - b. Air pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.
 - c. Design coils to be drainable.
 - 1) Coils shall have all circuits drainable when coils are installed in horizontal position and level.
 - 2) Coil headers shall be furnished with a drain connection at lowest point on header.
 - d. Vents: Vent connection at highest point on header.
 - e. Coils supply and return piping connections on same end of coil.
 - f. Coils shall be rated for system operating pressures and temperatures encountered by installation, but not less than **<Insert pressure>**.
 - g. Coil selection criteria, unless otherwise indicated on Drawings, are as follows:
 - 1) Face Velocity: Maximum of **[500 fpm (2.5 m/s)]<Insert value>**.
 - 2) Fin Height: Maximum of **[48 inches (1200 mm)]<Insert dimension>**.
 - 3) Fin Spacing: Maximum of **[12 fins per inch (2.1 mm)]<Insert spacing>**.

7. Casing and Tube Sheets:

- a. Depth: Extend coil casing and tube sheets a minimum of [1/2 inch (13 mm)]<Insert dimension> beyond face of fins on both entering and leaving side.
- b. Casing and Tube Sheet Materials:
 - 1) Stainless steel, ASTM A240/A240M or ASTM A480/A480M, [Type 304L][or][Type 316L], No. 2D finish.
 - 2) Galvanized steel, ASTM A653/A653M, **G90 (Z275)** coating.
- c. Top and Bottom Casings:
 - 1) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>; double flange edge for rigidity and ease of removal with secondary flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
 - 2) Thickness:
 - a) Coils with Fin Length of up to [72 Inches (1800 mm)]<Insert dimension>: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - b) Coils with Fin Length Exceeding [72 Inches (1800 mm)]<Insert dimension>: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
- d. End Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>.
 - 3) Thickness: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
- e. Intermediate Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Space intermediate tube sheets a maximum of [48 inches (1200 mm)]<Insert dimension> o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 - 3) Flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
 - 4) Thickness: Minimum of [16 gauge (1.6 mm)]<Insert thickness> thick.
- f. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

8. Fins:

- a. Materials:
 - 1) Aluminum: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 2) Copper: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 3) 90/10 Cupronickel: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.

- b. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 - c. Fin Configuration: **[Flat face fins without ripples][Flat face or enhanced ripple fins as required by performance]**.
- 9. Headers:
 - a. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.
 - b. Tube-to-Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than **0.12 inch (3 mm)**.
 - c. Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.
 - d. Drains: Include low point of headers with a **[NPS 1/2 (DN 13)]<Insert pipe size>** drain connection. Extend copper or **[red brass][carbon steel][stainless steel]<Insert material>** pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - e. Vents: Include high point of headers with a **[NPS 1/2 (DN 13)]<Insert pipe size>** vent connection. Extend copper or **[red brass][carbon steel][stainless steel]<Insert material>** pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - f. Supply and Return Connections:
 - 1) Terminate ends with MNPT.
 - 2) Connections to header shall be either copper tube with brazed ASME B16.18 threaded male adapters or **[red brass][carbon steel][stainless steel]<Insert material>** pipe with machine-threaded MNPT connections. Pipe shall extend through air-handling unit casing and be threaded on both ends to facilitate easy field removal and replacement.
 - 3) Connections **[NPS 2-1/2 (DN 65)]<Insert pipe size>** and larger shall have a bronze ASME 16.24 threaded flanges attached to threaded connections to provide for a flanged field connection. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
 - g. Protect openings of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into the coil.
- 10. Tubes:
 - a. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper; **[90/10 cupronickel alloy, ASTM B122/B122M]**.
 - b. Tube Nominal Diameter: **5/8 or 1 inch (16 or 25 mm)** before expanding, selected to provide performance indicated.
 - c. Tube Nominal Wall Thickness: As required by performance, minimum of **[0.035 inch (0.9 mm)][0.049 inch (1.2 mm)]<Insert dimension>** thick.
- 11. Tube Return Bends: 180-degree bends brazed to tubes; material[, **wall thickness,**] and nominal diameter to match tubes.
 - a. Tube Return Bend Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch (0.5 mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension>** thick.

12. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.
13. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
14. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:
 - a. Baked phenolic.
 - b. Cathodic epoxy.
 - c. Water-based flexible epoxy polymer.
 - d. Water-based synthetic flexible polymer.
 - e. **<Insert coating type>**.
15. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304][or][Type 316]** stainless steel.
16. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. Coil fin length.
 - g. Coil fin height.
 - h. Coil weight with fluid/without fluid.
 - i. Coil casing material and thickness.
 - j. Coil fin material and thickness.
 - k. Coil tube material and thickness.
 - l. Coil header material and thickness.
 - m. **<Insert requirements>**.
17. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
18. Air-Handling Unit Factory Assembly:
 - a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches (100 mm)]<Insert dimension>** beyond exterior face of the access panel as seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Include each coil with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct frame work from aluminum[, **galvanized steel**,] or stainless steel[**structural shapes**].

Q. Heating Coils With Integral Face-and-Bypass Dampers:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [LJ Wing; a Mestek Technology, Inc. company]
 - b. [Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [LJ Wing; a Mestek Technology, Inc. company]
 - b. [Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]
 - c. <Insert manufacturer's name>
3. Source Limitations: Obtain coils from single source from single manufacturer.
4. General: Provide air-handling units with heating coils with integral face-and-bypass dampers where indicated on Drawings.
5. Description: Horizontal or vertical tube arrangement as indicated on Drawings with integral face-and-bypass dampers and controls installed to control modulating dampers to achieve discharge air temperature set point.
 - a. Each coil consisting of multiple finned heating elements, each with bypasses and interlocking dampers controlled by electric actuators and a discharge airstream thermostat.
6. Performance:
 - a. Each coil able to maintain constant discharge air temperature regardless of variations in entering-air temperature with constant [steam][and][water] flow through coil.
 - b. Portioning of air across and around the heating element shall result in a uniform temperature within **5 deg F (3 deg C)** of average temperature when measured anywhere across a vertical plane located [24 inches (600 mm)][36 inches (900 mm)] downstream of leaving face of coil.
7. Casing: [Galvanized steel][or][Type 304 stainless steel], minimum of **16 gauge (1.6 mm)** thick. Standard casing shall be extended if required air-handling unit manufacturer to accommodate installation arrangement inside of the air-handling unit.
8. Fins: Rectangular shape, constructed of **0.010-inch- (0.25-mm-)** thick aluminum with spacing not closer than **12 fins per inch (2.1 mm)**.
9. Headers: [Carbon steel][or][copper], of thickness selected by manufacturer for flow, pressure, and temperature encountered; drain connections at low points, vent connections at high points, and supply and return connections located on discharge face of coil.
 - a. Insulation: Insulate headers with mineral-fiber insulation covered by a metal jacket.
 - b. Supply and Return Connections:
 - 1) Terminate ends with MNPT.
 - 2) Connections [NPS 2-1/2 (DN 65)]<Insert pipe size> and larger shall have thread-on flanges. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
10. Tubes:
 - a. Materials: [Copper][90/10 cupronickel][or][carbon steel].

- b. Nominal Diameter: **5/8 inch (16 mm)**.
 - c. Nominal Tube Wall Thickness: As required by performance, minimum of **[0.035 inch (0.9 mm)][0.049 inch (1.2 mm)]** thick.
- 11. Dampers: Clamshell design arranged to modulate airflow across or around individual heating elements. Constructed of **[galvanized steel][or][Type 304 stainless steel]**, minimum of **16 gauge (1.6 mm)** thick.
 - 12. Damper Actuators: **[Face][or side]** mounted; electric motor for proportional control, failing in last position.
 - 13. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.
 - 14. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
 - 15. Coatings: Where indicated on Drawings, coat coil casings and damper assemblies with **[air-dried alkyd enamel][or][baked-epoxy]** corrosion-resistant coating.
 - 16. Hardware: Use hex-head bolts, nuts, and washers constructed of **[zinc-plated carbon steel][or][Type 304 stainless steel]**.
 - 17. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. **<Insert requirements>**.
 - 18. Air-Handling Unit Factory Assembly:
 - a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches (100 mm)]<Insert dimension>** beyond exterior face of the access panel as seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Include each coil with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct frame work from aluminum[, **galvanized steel,**] or stainless steel[**structural shapes**].

R. Drain Pans:

- 1. General:
 - a. Include a drain pan for each cooling[**and heating**] coil and at other locations indicated.
 - b. Continuously weld drain pan seams, joints, and mitered corners to make the assembled drain pan watertight.
 - c. Drain pans shall be located under the entire coil and provide full coil coverage including coil return bends and headers.
 - d. Slope drain pans in multiple directions toward low point drain connection at a uniform slope

- of at least [1][2] percent from high point to low point.
 - e. Include stainless steel blank-offs to prevent air from bypassing around coil.
- 2. Intermediate Drain Pans:
 - a. Where multiple individual horizontally mounted coils are vertically stacked to make a coil bank, install intermediate drain pans under each stacked coil in the coil bank.
 - b. Material: [Type 304L][Type 316L][300 series] stainless steel ASTM A240/A240M or ASTM A480/A480M, a minimum of [16 gauge (1.6 mm)]<Insert value> thick.
 - c. Minimum Depth: [1.0 inch (25 mm)][1.5 inches (38 mm)]<Insert dimension>.
 - d. Extend drain pan beyond air entering face of coil casing at least [3 inches (75 mm)]<Insert distance>.
 - e. Extend drain pan beyond air leaving face of coil casing at least [6 inches (150 mm)]<Insert distance>.
 - 1) Where moisture eliminators are required to prevent moisture carryover, extend drain pan beyond leaving face of moisture eliminator in lieu of leaving face of coil.
 - f. Drain Pan Connection:
 - 1) Stainless steel threaded coupling welded to underside of drain pan at lowest point.
 - 2) Minimum Nominal Connection Size: [NPS 1 (DN 25)][NPS 1.5 (DN 40)][NPS 2 (DN 50)]<Insert pipe size>.
 - g. Drain Pipe:
 - 1) Air-handling unit manufacturer to connect full-size drain pipe to each drain pan connection. Option to use one of following pipe materials:
 - a) Copper tube with a bronze threaded male adapter, brazed or solder to end.
 - b) Aluminum pipe with threaded MNPT ends.
 - c) Stainless steel pipe with threaded MNPT ends.
 - 2) Extend drain pipe to top of drain pan immediately below.
 - 3) Include a removable stainless steel support to secure bottom of drain pipe from drain pan below to prevent lateral movement.
 - 4) In applications where multiple drain pans are stacked, align stacked drains pan connections and pipes for clear vertical flow.
- 3. Bottom Drain Pans:
 - a. Mounting Location, Recessed in Floor: Air-handling unit manufacturer has option to recess bottom drain pan into the floor or install drain pan above air-handling unit floor walking surface.
 - b. Mounting Location, Above Floor: Bottom drain pan shall be installed above air-handling unit floor walking surface. Do not recess drain pan into unit base.
 - c. Grating: Install removable stainless steel grating on top of drain pan.
 - d. Double-Wall Construction: Double-wall sheet with space between walls filled with [1-inch (25-mm)]<Insert thickness> insulation.
 - e. Material: [Type 304L][Type 316L][300 series] stainless steel ASTM A240/A240M or ASTM A480/A480M, a minimum of [16 gauge (1.6 mm)]<Insert value> thick.
 - f. Minimum Depth: [1.5 inches (38 mm)]<Insert depth>.
 - g. Extend drain pan beyond air entering face of coil casing at least [3 inches (75 mm)]<Insert distance>.
 - h. Extend drain pan beyond air leaving face of coil casing at least [12 inches (150 mm)]<Insert distance>.

- 1) Where moisture eliminators are required to prevent moisture carryover, extend drain pan beyond leaving face of moisture eliminator in lieu of the leaving face of coil.
- i. Drain Pan Connection:
 - 1) Stainless steel threaded half-coupling welded to lowest point of drain pan.
 - 2) Location: **[one end][both ends][See Drawings]<Insert requirement>**.
 - 3) Minimum Nominal Connection Size: **[NPS 1 (DN 25)][NPS 1.5 (DN 40)][NPS 2 (DN 50)]<Insert pipe size>**.
- j. Drain Pipe:
 - 1) Air-handling unit manufacturer to connect full size drain pipe to each drain pan connection. Option to use one of following pipe materials:
 - a) Copper tube with threaded male adapter, brazed or soldered to ends.
 - b) Aluminum pipe with threaded MNPT ends.
 - c) Stainless steel pipe with threaded MNPT ends.
 - 2) Extend drain pipe and terminate **[3 inches (75 mm)]<Insert distance>** beyond exterior face of casing.

S. Electric Heaters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Brasch Manufacturing Co., Inc]**
 - b. **[Chromalox, Inc.]**
 - c. **[INDEECO]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Brasch Manufacturing Co., Inc]**
 - b. **[Chromalox, Inc.]**
 - c. **[INDEECO]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain heaters from single source from single manufacturer.
4. General:
 - a. Provide air-handling units with electric heaters where indicated on Drawings.
 - b. NRTL listed for zero clearance to combustible surface, regardless of heater capacity.
5. Design and Performance:
 - a. Heaters and installation shall comply with NFPA 70.
 - b. Scheduled capacity (kW) is minimum acceptable.
 - c. Air pressure drop and face velocity are maximum acceptable.
 - d. Rate heaters output capacity at voltage, phase, and hertz indicated on Drawings.

- e. Arrange capacity control to minimize stratification.
 - f. Equally balance heater electrical load for each step across all three phases.
 - g. Part-Load Operation: Include multiple heaters configured in a **[series][or][parallel]** arrangement with operation staged if required for uninterrupted heater operation over the full range of air-handling unit airflow down to the minimum airflow indicated.
 - 1) Where multiple heaters positioned in a parallel arrangement are required for operation over the full range of air-handling unit airflow, include an automatic isolation damper at the **[inlet][or][discharge]** of inactive heaters to isolate airflow across inactive heaters while other heaters are operating.
6. Heating Elements:
- a. Open Elements:
 - 1) Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in a frame.
 - 2) Safety Screens: Install safety screens to protect operators from accidentally coming in direct connect with elements.
 - b. Finned Tubular Elements:
 - 1) Coiled resistance wire of 80 percent nickel and 20 percent chromium; center-mounted and surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
 - 2) Finish finned tubular elements with a baked-on aluminum paint, and mount in a frame.
 - 3) Each element individually removable from terminal box.
 - 4) Use threaded stainless steel element terminals and hardware.
7. Frame: **[Galvanized][or][stainless]** steel; include intermediate element support brackets equally spaced at a maximum of **[36 inches (900 mm)]<Insert distance>** o.c. across heater element length.
8. Terminal Box/Control Panel: **[Unit mounted][Remote mounted][Unit or remote mounting arrangement indicated on Drawings]**; with disconnection means and overcurrent protection.
- a. Enclosure: NEMA 250, **[Type 1][or][Type 12]** enclosure complying with UL 50.
 - b. Full face hinged door **[with lock and key latching device(s)]**.
 - c. Factory insulate base of terminal box to prevent condensation from occurring within box.
 - d. Mount terminal box control panel on exterior surface of air-handling unit casing. Gasket and seal air-handling unit cabinet penetrations.
 - e. Install a laminated elementary wiring diagram on inside face of heater control panel door or in another protected location than visible be service personnel. Wiring diagram shall match installation.
9. Controls:
- a. Safety Controls: Each heater with following factory-mounted safety controls:
 - 1) Disk-type thermal cutout switch with automatic reset.
 - 2) Primary linear thermal limit cutout switch with automatic reset.
 - 3) Secondary linear thermal limit cutout switch with local manual reset.
 - 4) Airflow Proving Switch: Diaphragm-operated pressure differential type; with pressure range selected to ensure reliable operation throughout full range of air-handling unit airflow down to minimum airflow indicated.

- b. Staging Control: Magnetic contactors for switching stages of heat except for air-handling units located in occupied spaces, include mercury contactors for switching stages of heat.
 - c. SCR Control: Silicon-controlled rectifier (SCR) for 100 percent stepless capacity control.
 - d. Remote Monitoring and Control: Include control devices necessary to interface with remote-control signals including the following:
 - 1) Heater on/off control.
 - 2) Monitoring heater on/off status.
 - 3) High-temperature alarm.
 - 4) Low-airflow alarm.
 - 5) Heater capacity control.
 - 6) **<Insert requirements>**.
10. Electrical:
- a. Single-Point Field Power Connection: Install and wire the heater to accommodate a single field electrical connection for electrical power.
 - b. Disconnecting Means: Provide each heater with a main electrical power, door mounted and interlocking, and disconnecting means to prevent access into panel, unless switched in the off position.
 - 1) **[Fused disconnect switch][Nonfused disconnect switch][Circuit breaker]** with lockable handle.
 - 2) Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert value> A**.
 - c. Factory install and wire branch circuit fusing, or circuit breakers in accordance with NFPA 70.
 - d. Pilot Lights: Include labeled pilot lights on face of control panel for the following:
 - 1) Power on.
 - 2) Low-airflow alarm.
 - 3) High-temperature alarm.
 - 4) One for each stage on.
 - 5) **<Insert requirement>**.
 - e. Terminations: Wire terminations and field interface terminations to labeled terminal strips.
 - f. Control Transformer: Size control circuit transformer for required load, plus 75 VA.
 - g. Labeling: Label each electrical device with a laminated phenolic tag.
 - h. Use only NRTL-labeled electrical components.
11. Nameplate: Include the following data:
- a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. **<Insert requirements>**.
12. Air-Handling Unit Factory Assembly:
- a. Support individual heater assemblies within unit from a structural framework constructed of **[aluminum][galvanized steel][or][stainless steel]**.
 - b. Provide each heater assembly with access from **[downstream][and][or][upstream]** sides.

- c. Make provisions in arrangement and installation to mitigate uneven airflow patterns within unit for proper heater operation.
- T. Direct-Steam-Injection Panel Distribution Manifold Humidifiers:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[DriSteem]**
 - c. **[Nortec Industries Inc.]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[DriSteem]**
 - c. **[Nortec Industries Inc.]**
 - d. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain humidifiers from single source from single manufacturer.
 - 4. Description: Prefabricated, direct-steam panel distribution manifold specially designed for steam dispersion in a short distance.
 - a. **[Horizontal][or][vertical]** header with multiple **[vertical][or][horizontal]**, **[nonsteam][steam]**-jacketed tubes.
 - b. **[Nozzles/metered orifices in conjunction with nonsteam-jacketed manifolds][or][punched orifices/no nozzles in conjunction with steam-jacketed manifolds]** spaced evenly along manifold tubes and providing dry and uniform steam distribution.
 - 5. Design and Performance:
 - a. Absorption distance within **[12 inches (300 mm)][18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>**.
 - b. Air Pressure Drop: Less than **0.1 inch wg (25 Pa)** at design velocity.
 - c. Suitable for pressurized steam applications.
 - 6. Headers and Distribution Tubes:
 - a. Material: **[Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
 - b. Insulation: **[Uninsulated][Insulated][Insulated, minimum R-0.5]**.
 - 7. Steam Separator: External separator, or separator/baffles integral to header, to provide condensate-free steam to the distribution tubes.
 - a. Material: **[Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
 - 8. Steam Trap:
 - a. Material: **[Cast iron][Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.

- b. Type: **[Inverted bucket][or][float and thermostatic]**.
- c. Capacity: Sized for a minimum of **[3]<Insert number>** times the maximum rated condensate flow of humidifier at **[1/2-psig (3.4-kPa)]<Insert value>** differential pressure.

9. Air-Handling Unit Factory Installation:

- a. Air-handling unit manufacturer shall furnish and install humidifiers with the size and capacities indicated on Drawings.
- b. Extend humidifier piping through the air-handling unit casing and terminate the connections approximately **[4 inches (100 mm)]<Insert distance>** beyond the exterior face.
- c. Drain Pans: Install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
- d. Provide each humidifier with access for inspection, service, and replacement.
- e. Each humidifier shall be removable for replacement through a removable access panel in the air-handling unit casing or an access door.
- f. Include a freestanding and self-supporting structural **[aluminum or]**stainless steel framework to support each humidifier.

U. Bag Filters:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain filters from single source from single manufacturer.
- 4. Description: Factory-fabricated, dry, extended-surface, unsupported filters with header frames.
- 5. Performance:
 - a. Filtration Efficiency, ASHRAE 52.2 MERV Rating:
[11][11A][13][13A][14][14A][15][15A][See Drawings].
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500 fpm (2.5 m/s)**, pressure drop shall not exceed the following:
 - 1) MERV 11 and MERV 11A:
 - a) Depth 12 Inches (300 mm): **0.28 inch wg (70 Pa)**.
 - b) Depth 15 Inches (375 mm): **0.26 inch wg (65 Pa)**.

- c) Depth 22 Inches (550 mm): **0.24 inch wg (60 Pa)**.
 - d) Depth 30 Inches (750 mm): **0.23 inch wg (58 Pa)**.
 - 2) MERV 13 and MERV 13A:
 - a) Depth 12 Inches (300 mm): **0.52 inch wg (130 Pa)**.
 - b) Depth 15 Inches (375 mm): **0.48 inch wg (120 Pa)**.
 - c) Depth 22 Inches (550 mm): **0.38 inch wg (95 Pa)**.
 - d) Depth 30 Inches (750 mm): **0.34 inch wg (85 Pa)**.
 - 3) MERV 14 and MERV 14A:
 - a) Depth 12 Inches (300 mm): **0.67 inch wg (168 Pa)**.
 - b) Depth 15 Inches (375 mm): **0.55 inch wg (138 Pa)**.
 - c) Depth 22 Inches (550 mm): **0.45 inch wg (113 Pa)**.
 - d) Depth 30 Inches (750 mm): **0.41 inch wg (103 Pa)**.
 - 4) MERV 15 and MERV 15A:
 - a) Depth 15 Inches (375 mm): **0.81 inch wg (203 Pa)**.
 - b) Depth 22 Inches (550 mm): **0.62 inch wg (155 Pa)**.
 - c) Depth 30 Inches (750 mm): **0.53 inch wg (133 Pa)**.
 - d. Manufacturer-Recommended Final Air Pressure Drop: **[1.0 inch wg (250 Pa)]<Insert pressure drop>**.
 - e. Pressure Differential without Failure: **[10 inches wg (2500 Pa)]<Insert pressure drop>**.
 - f. Temperature Rating: **[158 deg F (70 deg C)]<Insert temperature>**.
- 6. Certification:
 - a. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
 - b. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
 - c. UL: UL 900 listed.
- 7. Size:
 - a. Nominal size of individual filters indicated on Drawings:
 - b. Nominal Filter Size:
 - 1) Face: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
 - 2) Depth: **[12 inches (300 mm)][15 inches (375 mm)][22 inches (550 mm)][30 inches (750 mm)]<Insert dimension>**.
 - c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
- 8. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face:
 - a. Depth 12 Inches (300 mm): **39 sq. ft. (3.6 sq. m)**.
 - b. Depth 15 Inches (375 mm): **49 sq. ft. (4.5 sq. m)**.
 - c. Depth 22 Inches (550 mm): **71 sq. ft. (6.6 sq. m)**.
 - d. Depth 30 Inches (750 mm): **97 sq. ft. (9.0 sq. m)**.
- 9. Construction:

- a. Media: Glass-fiber material constructed so individual pockets are maintained in tapered form under rated-airflow conditions by flexible internal supports. **[Coat media with an antimicrobial agent.]**
 - 1) Synthetic mesh backing to provide media protection and support.
 - 2) Multiple stitched pockets sealed to eliminate air bypass through stitch points.
- b. Header: Filter face with ABS plastic or corrosion-resistant metal header designed for rigidity and to eliminate racking.
- c. Adhesive: Fire-retardant bonding adhesive where bonding media to header.

V. Cartridge Filters:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain filters from single source from single manufacturer.
- 4. Description: Factory-fabricated, dry, extended-surface, disposable, air filters with media formed in mini-pleats and arranged in a V-shape pattern.
- 5. Performance:
 - a. Filtration Efficiency, ASHRAE 52.2 MERV Rating: **[11][11A][13][13A][14][14A][16][16A][See Drawings].**
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500 fpm (2.5 m/s)**, clean filter pressure drop shall not exceed the following:
 - 1) MERV 11 and MERV 11A: **0.21 inch wg (53 Pa).**
 - 2) MERV 13 and MERV 13A: **0.25 inch wg (63 Pa).**
 - 3) MERV 14 and MERV 15A: **0.27 inch wg (68 Pa).**
 - 4) MERV 16 and MERV 16A: **0.60 inch wg (150 Pa).**
 - d. Manufacturer-Recommended Final Air Pressure Drop: **[1.5 inches wg (375 Pa)]<Insert pressure drop>**.
 - e. Pressure Differential without Failure: **[10 inches wg (2500 Pa)]<Insert pressure drop>**.
 - f. Temperature Rating: **[175 deg F (79 deg C)]<Insert temperature>**.

6. Certification:
 - a. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
 - b. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
 - c. UL: UL 900 listed.
 7. Size:
 - a. Nominal size of individual filters indicated on Drawings:
 - b. Nominal Filter Size:
 - 1) Face: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
 - 2) Depth: **12 inches (300 mm)**.
 - c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
 8. Filter Media Surface Area: Each filter shall contain at least **[200 sq. ft. (18.6 sq. m)]<Insert area>** for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face.
 9. Construction:
 - a. Media: Microfine glass media formed into mini-pleats and arranged in V-shape patterns.
 - b. Media Frame: Plastic or corrosion-resistant metal.
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to frame.
- W. Pleated Panel Filters:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain filters from single source from single manufacturer.
 4. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters.
 5. Performance:
 - a. Filtration Efficiency, ASHRAE 52.2 MERV Rating: **[8][8A][9][9A][See Drawings]**.
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500 fpm (2.5 m/s)**, clean filter pressure drop shall not exceed the following:

- 1) MERV 8 and MERV 8A:
 - a) Depth 1 Inch (25 mm): **0.23 inch wg (58 Pa)**.
 - b) Depth 2 Inches (50 mm): **0.31 inch wg (78 Pa)**.
 - c) Depth 4 Inches (100 mm): **0.27 inch wg (68 Pa)**.
- 2) MERV 9 and MERV 9A:
 - 3) Depth 2 Inches (50 mm): **0.30 inch wg (75 Pa)**.
 - 4) Depth 4 Inches (100 mm): **0.27 inch wg (68 Pa)**.
- d. Manufacturer-Recommended Final Air Pressure Drop: **[1.0 inch wg (250 Pa)]<Insert pressure drop>**.
- e. Pressure Differential without Failure: **[2 inches wg (500 Pa)]<Insert pressure drop>**.
- f. Temperature Rating: **[200 deg F (93 deg C)]<Insert temperature>**.
6. Certification:
 - a. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
 - b. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
 - c. UL: UL 900 listed.
7. Size:
 - a. Nominal size of individual filters indicated on Drawings:
 - b. Nominal Filter Size:
 - 1) Face: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
 - 2) Depth: **[1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)]**.
 - c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
8. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face:
 - a. Depth 1 Inch (25 mm): **9.8 sq. ft. (0.9 sq. m)**.
 - b. Depth 2 Inches (50 mm): **17.3 sq. ft. (1.6 sq. m)**.
 - c. Depth 4 Inches (100 mm): **27.7 sq. ft. (2.6 sq. m)**.
9. Construction:
 - a. Media: **[Glass or][Cotton and]** synthetic blend of fibers arranged in a series of pleats attached to and supported by a corrosion-resistant welded-wire grid. **[Coat media with an antimicrobial agent.]**
 - b. Filter Media Casing: High wet strength (28-point) beverage board that is bonded around the periphery to eliminate air bypass.
 - 1) Diagonal support members across upstream and downstream filter face constructed of same material as casing shall ensure pleat spacing and stability.
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to casing.
- X. ASHRAE-Rated Filter Holding Frames:
 1. Filter Holding Frames for ASHRAE-Rated Filters:

- a. Fabricate filter holding frames with mitered corners and reinforce frame to maintain a durable, rugged, true square shape.
 - b. Construct frames of **[galvanized][or][stainless]** steel. Use stainless steel frames in applications exposed to corrosive airstreams.
 - c. For applications with pre-filter and final filters sharing the same filter holding frame, frames shall be suitable for supporting and holding both pre-filter and final filters in frame with both filters serviceable from upstream (entering air) side.
 - d. Frame Depth: At least **[2.75 inches (70 mm)]<Insert dimension>**.
 - e. Gaskets: Continuous, suitable for same operating temperature as filters.
 - f. Filter Clips: Each filter holding frame with spring clip fasteners at each corner. Spring clips shall allow filters to be removed and replaced without use of tools.
 - g. Frames shall be industry-standard size to provide interchangeability of filters from other manufacturers.
2. Air-Handling Unit Factory Installation:
- a. Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.
 - b. Furnish filter quantity, size, type, and performance indicated on Drawings.
 - c. Install filter frames in a flat vertical position for horizontal airflow.
 - d. Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.
 - e. Secure individual holding frames together to build a multiple filter bank.
 - f. Construct **[aluminum][galvanized-steel][or][stainless steel]** support structure to hold frames and filters.
 - 1) Design support structure for maximum system operating pressures encountered equal to fan shutoff pressure.
 - 2) Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a **[200-lb (890-N)]<Insert value>** lateral force applied at any point on the filter holding frame assembly.

Y. Absolute Filters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain filters from single source from single manufacturer.
4. Description: Factory-fabricated, disposable, packaged high-efficiency particulate air filters consisting of an anodized aluminum hold frame with media formed into mini-pleats and arranged

- in a V-shape pattern.
5. Performance:
- a. Filtration Efficiency:
 - 1) Rating indicated on Drawings.
 - 2) IEST Rating at 0.3-micron Size: **[95][99.99][99.999]<Insert number>** percent.
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500-fpm (2.5-m/s)**, clean filter pressure drop shall not exceed the following:
 - 1) Gasket Seal Filters:
 - a) 95 Percent Efficiency: **0.50 inch wg (125 Pa)**.
 - b) 99.99 Percent Efficiency: **1.0 inch wg (250 Pa)**.
 - c) 99.999 Percent Efficiency: **1.1 inches wg (275 Pa)**.
 - 2) Gel Seal Filters:
 - a) 95 Percent Efficiency: **0.70 inch wg (175 Pa)**.
 - b) 99.99 Percent Efficiency: **0.9 inch wg (225 Pa)**.
 - c) 99.999 Percent Efficiency: **1.1 inches wg (250 Pa)**.
 - d. Manufacturer-Recommended Final Air Pressure Drop: **[2.0 inches wg (500 Pa)]<Insert pressure drop>**.
 - e. Pressure Differential without Failure: **[10 inches wg (2500 Pa)]<Insert pressure drop>**.
 - f. Temperature Rating:
 - 1) Gasket Seal: **[175 deg F (79 deg C)]<Insert temperature>**.
 - 2) Gel Seal: **[155 deg F (68 deg C)]<Insert temperature>**.
6. Certification:
- a. IEST: Tested and rated in accordance with IEST's "Recommended Practice for Testing HEPA Filters."
 - 1) Comply with IEST-RP-CC001.6.
 - 2) Comply with IEST-RP-CC034.
 - b. UL: UL 900 listed.
7. Size:
- a. Nominal Face Size: **[24 by 24 inches (600 by 600 mm)][See Drawings]<Insert size>**.
 - b. Depth: **12 inches (300 mm)**.
 - c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
8. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face:
- a. Gasket Seal:
 - 1) 95 Percent Efficiency: **390 sq. ft. (36.2 sq. m)**.

- 2) 99.99 Percent Efficiency: **390 sq. ft. (36.2 sq. m).**
 - 3) 99.999 Percent Efficiency: **431 sq. ft. (40.0 sq. m).**
 - b. Gel Seal:
 - 1) 95 Percent Efficiency: **401 sq. ft. (37.2 sq. m).**
 - 2) 99.99 Percent Efficiency: **401 sq. ft. (37.2 sq. m).**
 - 3) 99.999 Percent Efficiency: **401 sq. ft. (37.2 sq. m).**
9. Construction for Gasket Seal Filters:
 - a. Media: Microfine glass media formed into mini-pleats and arranged in a V-shape pattern.
 - 1) Internal Separators: **[None]<Insert type>.**
 - 2) Media to Filter Frame Seal Material: **[Polyurethane]<Insert material>.**
 - 3) Faceguard Material: **[Aluminum][Stainless steel]<Insert material>.**
 - 4) Faceguard Location: **[None][upstream][and][downstream].**
 - b. Media-Holding Frame: Anodized aluminum enclosing frame with continuous seamless perimeter **[neoprene]<Insert gasket material>** gasket.
 - 1) Filter Frame to Mounting Frame Seal Location: **[Upstream][Downstream].**
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to frame.
10. Construction for Gel Seal Filters:
 - a. Media: Microfine glass media formed into mini-pleats and arranged in a V-shape pattern.
 - 1) Internal Separators: **[None]<Insert type>.**
 - 2) Media to Filter Frame Seal Material: **[Polyurethane]<Insert material>.**
 - 3) Faceguard Material: **[Aluminum][Stainless steel]<Insert material>.**
 - 4) Faceguard Location: **[None][upstream][and][downstream].**
 - b. Media-Holding Frame: Anodized aluminum enclosing frame with gel seal track and elastic **[silicone][urethane]<Insert material>** gel sealant.
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to frame.
- Z. Absolute Filter Holding Frame Assembly:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**



- b. [Camfil Farr Inc.]
 - c. [Flanders Corporation]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain holding frame assembly from absolute filter manufacturer.
4. Description: Holding frame assembly with access for upstream (front) or downstream (back) filter servicing as indicated, specifically designed for absolute filter banks.
- a. Gasket Seal: Positive-sealing device to ensure seal between each gasket filter to prevent bypass of unfiltered air. Filter latching mechanism to seat each filter firmly against holding frame surface.
 - b. Gel Seal: Knife-edge to mate to each filter to prevent bypass of unfiltered air. Positive-locking mechanism for each filter to seat the knife edge into the gel during installation and to remove the filter from the knife edge during filter replacement.
5. Construction:
- a. Each filter bank with a factory-assembled filter holding framework consisting of a framework superstructure, a base, bracing, and removable swing bolt assemblies designed to accommodate the scheduled sizes and configuration of absolute filters.
 - b. Framework:
 - 1) Nominal **4 inches (100 mm)**, minimum **11-gauge- (3.1-mm)** thick-, [**galvanized-steel**][or][**stainless steel**] channels or tube.
 - 2) Continuously weld members. After assembly, grind and polish welds to provide a smooth uniform sealing surface.
 - c. Base:
 - 1) Continuously weld the framework to a minimum **11-gauge- (3.1-mm-)** thick, [**galvanized-steel**][or][**stainless steel**] base.
 - d. Filter Attachment:
 - 1) Equip framework with four swing bolts for each filter.
 - 2) Include each swing bolt with a bearing clamp and hex nut designed for applying a sufficiently uniform sealing pressure against the periphery of each filter.
 - 3) Swing bolts shall be constructed of at least **5/16-inch (8-mm)** [**zinc electroplated**][**galvanized**][or][**stainless**] steel.
 - 4) Hex nuts shall be capable of being torqued to provide at least 50 percent gasket compression.
 - 5) Swing bolt assembly shall provide individual sealing of filters.
 - e. Pre-Filter Frames:
 - 1) For filter banks with pre-filters attached on the air entering side of absolute filter, include an ASHRAE-rated filter holding frame.
 - 2) Pre-filter holding frames shall be held in place by swing bolts and allow for installation and removal of pre-filters without disturbing absolute filter seal.
6. Air-Handling Unit Factory Installation:
- a. Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.
 - b. Furnish filter quantity, size, type, and performance indicated on Drawings.

- c. Install filter frames in a flat vertical position for horizontal airflow.
- d. Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.
- e. Construct aluminum[, **galvanized-steel**] or stainless steel support structure to hold frames and filters.
 - 1) Design support structure for maximum system operating pressures encountered equal to fan shutoff pressure.
 - 2) Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a **[400-lb (1780-N)]<Insert value>** lateral force applied at any point on the filter holding frame assembly.

AA. Gas-Phase Filters:

1. Gas-Phase Panel-Style Filters:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[AAF International]**
 - 2) **[Camfil Farr Inc.]**
 - 3) **[Flanders Corporation]**
 - 4) **[Koch Filter Corporation]**
 - 5) **[Purafil, Inc.]**
 - 6) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[AAF International]**
 - 2) **[Camfil Farr Inc.]**
 - 3) **[Flanders Corporation]**
 - 4) **[Koch Filter Corporation]**
 - 5) **[Purafil, Inc.]**
 - 6) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain filters from single source from single manufacturer.
- d. Description: Gas-phase panel filter for installation in a universal ASHRAE-rated filter holding frame.
- e. Performance:
 - 1) Initial Air Pressure Drop: Maximum **0.50 inch wg (125 Pa)** at a velocity of **500 fpm (2.5 m/s)**.
 - 2) Efficiency: 60 percent ozone-removal efficiency.
 - 3) Temperature: **155 deg F (68 deg C)**.
- f. Construction:
 - 1) Filters shall be plastic disposable, loose-fill sorbent[**or refillable**].
 - 2) Panel shall include perforated face.
 - 3) Each panel shall contain at least **12 lb (2.7 kg)** of sorbent.
- g. Nominal Panel Filter Size:

- 1) Face: **24 by 24 inches (600 by 600 mm)**.
- 2) Depth: **2 inches (50 mm)**.
- h. Media:
 - 1) Coconut shell activated carbon.
 - 2) Activated alumina impregnated with potassium permanganate.
 - 3) Blended activated carbon and alumina impregnated with potassium permanganate.
 - 4) **<Insert media types for specific applications>**.
- i. Pre-Installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption before installation.
- j. Gas-Phase Panel-Style Filter Holding Frames: Use ASHRAE-rated filter holding frames.
2. Gas-Phase Canister-Style Filters:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Camfil Farr Inc.]**
 - 2) **[Flanders Corporation]**
 - 3) **[Purafil, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Camfil Farr Inc.]**
 - 2) **[Flanders Corporation]**
 - 3) **[Purafil, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain filters from single source from single manufacturer.
 - d. Description: Factory-fabricated, dry, cylindrical canisters containing loose-fill adsorbent media.
 - e. Performance:
 - 1) Initial Air Pressure Drop: **0.60 inch wg (150 Pa)** at a velocity of **500 fpm (2.5 m/s)** when 16 cylinders, **24 inches (600 mm)** long are installed on frames.
 - 2) Efficiency: 95 percent removal efficiency at rated airflow.
 - 3) Temperature:
 - a) Plastic Construction: **105 deg F (41 deg C)**.
 - b) Stainless Steel Construction: **140 deg F (60 deg C)**.
 - f. Canister Construction:
 - 1) Material: **[Disposable ABS HDPE plastic][or][factory-refillable stainless steel]**.
 - 2) Perforations around cylinder surface area for air passage through media.
 - 3) Each canister shall include a mounting assembly with three integral bayonets for mounting to matching cylindrical mounting flange.
 - 4) Gasket seals.

- 5) Each canister with at least **1.5 lb (2.7 kg)** of sorbent per **6 inches (150 mm)** of canister length.
 - 6) Canister to mounting hardware procedure shall form a mechanical connection with a seal limiting air bypass across canister mounting assembly.
 - g. Filter Size:
 - 1) Nominal Holding Frame Face: **24 by 24 inches (600 by 600 mm)**.
 - 2) Nominal Canister Diameter: **6 inches (150 mm)**.
 - 3) Nominal Canister Length: **[18 inches (450 mm)][24 inches (600 mm)][Length indicated on Drawings]**.
 - h. Media:
 - 1) Activated carbon.
 - 2) Impregnated carbon for corrosive and acid gases.
 - 3) Activated alumina impregnated with 4 percent potassium permanganate.
 - 4) Blended activated carbon and activated alumina impregnated with potassium permanganate.
 - 5) **<Insert media types for specific applications>**.
 - i. Pre-Installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption before installation.
 - j. Canister-Style Gas-Phase Filter Holding Frames:
 - 1) Holding frames shall be **14-gauge (2-mm)** stainless steel with cylindrical sorbent cylinder mounting perforations.
 - 2) Frame shall be assembled from a single piece of metal and welded at junctures to assure a rigid and durable frame assembly.
 - 3) Each frame shall hold 16 canisters.
 - 4) Frame with prepunched mounting holes for cylindrical filter fastener attachment and open airflow paths.
 - 5) Frame designed for front or back loading.
 - 6) Frame surface shall have a flat sealing surface to ensure a secure sorbent canister mount when matched with sorbent cylinders and sealing gasket.
 - 7) Cylinder to mounting hardware procedure shall form a mechanical connection forming a tight seal that minimizes air bypass.
3. Air-Handling Unit Factory Installation:
- a. Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.
 - b. Furnish filter quantity, size, type, and performance indicated on Drawings.
 - c. Install filter frames in a flat vertical position for horizontal airflow.
 - d. Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.
 - e. Construct stainless steel support structure to hold frames and filters.
 - 1) Design support structure for weight of gas-phase filters and maximum system operating pressures encountered equal to fan shutoff pressure.
 - 2) Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a **[800-lb (3559-N)]<Insert value>** lateral force applied at any point on the filter holding frame assembly.

BB. Filter Gauges:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
 - a. Gauge: **<Insert manufacturer's name; product name or designation>**.
 - b. Vent Valves: **<Insert manufacturer's name; product name or designation>**.
 - c. Static Pressure Sensors: **<Insert manufacturer's name; product name or designation>**.
 - d. Tubing Compression Fittings: **<Insert manufacturer and product name or designation>**.
2. Provide a gauge to indicate pressure differential between entering and leaving side of each filter bank. Panel filter bank separate from cartridge filter bank.
 - a. Where multiple filters share a common frame, include a separate gauge for each filter bank.
 - b. Include a metal spacer constructed of same material as filter frame for one of the filters installed in filter bank to accommodate pressure differential measure across both upstream and downstream filters.
3. Gauge shall have a nominal **4-inch- (100-mm-)** diameter face.
4. Select range of gauge to be approximately **[twice][three times]<Insert range>** the dirty filter pressure drop.
5. Provide each gauge with vent valves to allow for re-zeroing the gauge without removing tubing connections.
6. Include static pressure sensors on entering and leaving side of each filter bank.
7. Air-Handling Unit Factory Assembly:
 - a. Mount each filter gauge on exterior surface of unit casing near associated filter sections.
 - b. Mount center of gauges **[60 inches (1500 mm)]<Insert distance>** above bottom of air-handling unit structural base.
 - c. Connect static pressure sensors to filter gauges using **[aluminum][copper][or][stainless steel]** tubing and compression type fittings.
 - d. Support tubing at intervals not greater than **[60 inches (1500 mm)]<Insert distance>** o.c.

CC. Automatic Dampers:

1. General: Provide air-handling units with automatic dampers where indicated on Drawings.
 - a. Unless otherwise indicated, use parallel-blade configuration for two-position control, for equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
 - b. Factory assemble multiple damper sections to provide a single damper assembly of size required by application.
 - c. Damper actuator shall be factory installed by damper manufacturer as integral part of damper assembly. Coordinate actuator location and mounting requirements with damper manufacturer.
2. Rectangular Dampers with Aluminum Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**

- 5) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [American Warming and Ventilating (AWV); Mestek, Inc.]
 - 2) [Greenheck Fan Corporation]
 - 3) [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - 4) [TAMCO (T. A. Morrison & Co. Inc.)]
 - 5) <Insert manufacturer's name>
- c. Source Limitations: Obtain dampers from single source from single manufacturer.
- d. Performance:
 - 1) Leakage: AMCA 511, Class 1A. Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
 - 2) Pressure Drop: **0.05 inch wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **[4000 fpm (20 m/s)][6000 fpm (30 m/s)]**.
 - 4) Temperature: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - 6) Damper shall have AMCA seal for both air leakage and air performance.
- e. Construction:
 - 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.07 inch (1.8 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.
 - 2) Blades:
 - a) Hollow, airfoil, extruded aluminum.
 - b) Parallel- or opposed-blade configuration as required by application.
 - c) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.07 inch (1.8 mm)** thick.
 - d) Width not to exceed **6 inches (150 mm)**.
 - e) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
 - b) Jams: Stainless steel, compression type[; **or replaceable, mechanically attached extruded silicone**].
 - 4) Axles: **0.5-inch- (13-mm-)** diameter, **[plated][or][stainless]** steel, mechanically attached to blades.
 - 5) Bearings:



- a) Molded synthetic or stainless steel sleeve mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
- 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.
- 7) Additional Corrosion Protection for Corrosive Environments:
 - a) Include anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of **0.0007 inch (0.018 mm)** thick.
 - b) Axles, damper linkage, and hardware shall be constructed of Type 316L grade stainless steel.
- f. Airflow Measurement: Where indicated, include damper assembly with integral airflow monitoring.
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain damper applications from single source from single manufacturer.
 - 4) Performance:
 - a) Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.
 - b) Accuracy shall be within 5 percent of actual flow rate between the range of minimum and design airflow. For applications with a large variation in range between the minimum and design airflow, configure damper sections and flow measurement assembly as required to comply with stated accuracy over the entire modulating range.
 - c) Include a straightening device as part of flow measurement assembly to achieve the specified accuracy with configuration indicated.
 - d) Suitable for operation in untreated and unfiltered air.
 - e) Include temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
 - f) Include automatic zeroing feature.
- g. Airflow Control: Where indicated, provide damper assembly with integral airflow measurement and control.

- 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
- 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
- 3) Source Limitations: Obtain damper assembly from single source from single manufacturer.
- 4) Performance:
 - a) A factory-furnished and -calibrated controller shall be programmed, in nonvolatile EPROM, with application-specific airflow set point and range.
 - b) Controller and actuator shall communicate to control the desired airflow.
 - c) Controller shall receive a zero- to 10-V dc input signal and report a zero- to 20-mA output signal that is proportional to airflow.
 - d) Airflow measurement and control range shall be suitable for operation between **150 to 2000 fpm (0.8 to 10 m/s)**.
 - e) Ambient Operating Temperature Range: **Minus 40 to plus 140 deg F (Minus 40 to plus 60 deg C)**.
 - f) Ambient Operating Humidity Range: 5 to 95 percent relative humidity, noncondensing.
 - g) Provide unit with control transformer rated for not less than 85 VA. Include transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.
 - h) Include screw terminals for interface to field wiring.
 - i) Factory mount electronics within a NEMA 250, Type 1 painted steel enclosure.
3. Rectangular Dampers with Insulated Aluminum Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**

- 3) [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - 4) [TAMCO (T. A. Morrison & Co. Inc.)]
 - 5) <Insert manufacturer's name>
- c. Source Limitations: Obtain dampers from single source from single manufacturer.
- d. General: Unless otherwise indicated on Drawings, install insulated aluminum blade dampers in applications where dampers close to outdoors.
- e. Performance:
- 1) Leakage: AMCA 511, Class 1A. Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure and shall not exceed **4.9 cfm/sq. ft. (25 L/s per sq. m)** against **4-inch wg (1000-Pa)** differential static pressure at **minus 40 deg F (minus 40 deg C)**.
 - 2) Pressure Drop: **0.1 inch wg (25 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **Minus 100 to plus 185 deg F (Minus 73 to plus 85 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - 6) Damper shall have AMCA seal for both air leakage and air performance.
- f. Construction:
- 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.08 inch (2.0 mm)** thick.
 - b) C-shaped channel with integral flange(s). Mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **4 inches (100 mm)**.
 - d) Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.
 - 2) Blades:
 - a) Hollow shaped, extruded aluminum.
 - b) Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
 - c) Parallel- or opposed-blade configuration as required by application.
 - d) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.08 inch (2.0 mm)** thick.
 - e) Width not to exceed **6 inches (150 mm)**.
 - f) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
 - 3) Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the aluminum extrusions. [**Option to use stainless steel compression-type frame seals.**].
 - 4) Axles: **0.44-inch- (11-mm-)** diameter [plated][or][stainless] steel, mechanically attached to blades.
 - 5) Bearings:
 - a) Bearings shall be composed of a celcon inner bearing fixed to axle, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.

- b) Where blade axles are installed in vertical position, include thrust bearings.
- 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.
- 7) Additional Corrosion Protection for Corrosive Environments:
 - a) Include anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of **0.0007 inch (0.018 mm)** thick.
 - b) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.
- 4. Industrial-Duty Rectangular Dampers with Steel Airfoil Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. Performance:
 - 1) Leakage: Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
 - 2) Pressure Drop: **0.06 inch wg (15 Pa)** at **2000 fpm (10 m/s)** across a **48-by-48-inch (1200-by-1200-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, minimum **10 inches wg (2500 Pa)**.
 - e. Construction:
 - 1) Frame:
 - a) Material: **[Galvanized steel][Type 304 stainless steel][or][Type 316L stainless steel]**, minimum **0.11 inch (2.8 mm)** thick.

- b) C-shaped channel with mating face minimum of **1 inch (25 mm)**.
 - c) Width not less than **[3 inches (75 mm)][blade width plus 2 inches (50 mm)]**.
 - 2) Blades: Hollow, airfoil shape; constructed of **[galvanized steel][Type 304 stainless steel][Type 316L stainless steel]**, minimum **0.06 inch (1.6 mm)** thick.
 - a) Width not to exceed **[6 inches (150 mm)][8 inches (200 mm)]**.
 - b) Length not to exceed **[36 inches (900 mm)][48 inches (1200 mm)][60 inches (1500 mm)]**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached EPDM or extruded silicone.
 - b) Jams: Stainless steel, double compression type.
 - 4) Axles: **0.5- or 0.75-inch- (13- or 19-mm-)** diameter **[plated][Type 304 stainless][or][Type 316 stainless]** steel, mechanically attached to blades **[and continuous from end to end]**.
 - 5) Bearings:
 - a) Stainless steel sleeve type mounted in frame.
 - b) Where blade axles are installed in vertical position, provide thrust bearings.
 - 6) Linkage:
 - a) Face linkage exposed to airstream.
 - b) Constructed of **[plated steel][Type 304 stainless steel][or][Type 316 stainless steel]**.
 - c) Hardware: **[Type 304][or][Type 316]** stainless steel.
- 5. Damper Actuators:
 - a. General:
 - 1) Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which damper is subjected.
 - 2) Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.
 - 3) Total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.
 - 4) Include one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.
 - 5) Avoid use of excessively oversized actuators, which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
 - 6) Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
 - 7) Include mounting hardware and linkages for connecting actuator to damper.
 - 8) Select actuators to fail in desired position in the event of a power failure.
 - 9) Actuator Fail Positions: **[See Drawings.][As indicated below:]**
 - a) Exhaust Air: **[Close][Last position][Open]**.
 - b) Outdoor Air: **[Close][Last position][Open]**.

- c) Supply Air: **[Close][Last position][Open]**.
 - d) Return Air: **[Close][Last position][Open]**.
 - e) **<Insert system and fail position>**.
- b. Type: Motor operated, with or without gears, electric and electronic.
- c. Voltage:
 - 1) **[See Drawings][Voltage selection is delegated to professional designing control system][24 V][120 V]<Insert requirement>**.
 - 2) Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
 - 3) Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.
- d. Construction:
 - 1) Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
 - 2) 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
 - 3) Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- e. Field Adjustment:
 - 1) Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
 - 2) Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when actuator is not powered.
- f. Two-Position Actuators: Single direction, spring return, or reversing type.
- g. Modulating Actuators:
 - 1) Capable of stopping at all points across full range, and starting in either direction from any point in range.
 - 2) Control Input Signal:
 - a) Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for **[0- to 10-][or][2- to 10-]V dc [and][4- to 20-mA]** signals.
 - b) Pulse-Width Modulation (PWM): Actuator drives to a specified position in accordance with a pulse duration (length) of signal from a dry-contact closure, triac sink, or source controller.
 - c) Programmable Multifunction:
 - d) Control input, position feedback, and running time shall be factory or field programmable.
 - e) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
 - f) Service data, including at a minimum, number of hours powered, and number of hours in motion.
- h. Position Feedback:
 - 1) **[Equip][Where indicated, equip]** two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of

- ## San Bernardino County, Specifications

NFPA requirements.

o. Sound:

- 1) Spring Return: 62 dBA.
- 2) Non-Spring Return: 45 dBA.

DD. Manual Balancing Dampers:

1. General: Air-handling unit manufacturer shall furnish and factory install manual balancing dampers inside air-handling units where indicated on Drawings.
2. Rectangular Manual Balancing Dampers with Aluminum Airfoil Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 3) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 3) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. Performance:
 - 1) Leakage: AMCA 511, Class 1A. Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
 - 2) Pressure Drop: **0.05 inch wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **6000 fpm (30 m/s)**.
 - 4) Temperature: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - 6) Damper shall have AMCA seal for both air leakage and air performance.
 - e. Construction:
 - 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.07 inch (1.8 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.

- 2) Blades:
 - a) Hollow, airfoil, extruded aluminum.
 - b) Parallel- or opposed-blade configuration as required by application.
 - c) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.07 inch (1.8 mm)** thick.
 - d) Width not to exceed **6 inches (150 mm)**.
 - e) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
- 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
 - b) Jams: Stainless steel, compression type.
- 4) Axles: **0.5-inch- (13-mm-)** diameter **[plated][or][stainless]** steel, mechanically attached to blades.
- 5) Bearings:
 - a) Molded synthetic or stainless steel sleeve mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
- 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.
- 7) Locking Regulator:
 - a) Aluminum or stainless steel standoff with locking regulator mounted to frame in an accessible location for manual adjustment of damper blades.
- 8) Additional Corrosion Protection for Corrosive Environments:
 - a) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of **0.0007 inch (0.018 mm)** thick.
 - b) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.
3. Industrial-Duty Manual Balancing Dampers with Airfoil Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain dampers from single source from single manufacturer.
- d. Performance:
- 1) Leakage: Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
 - 2) Pressure Drop: **0.06 inch wg (15 Pa)** at **2000 fpm (10 m/s)** across a **48-by-48-inch (1200-by-1200-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, minimum **10 inches wg (2500 Pa)**.
- e. Construction:
- 1) Frame:
 - a) Material: **[Galvanized steel][Type 304 stainless steel][or][Type 316L stainless steel]**, minimum **0.11 inch (2.8 mm)** thick.
 - b) C-shaped channel with mating face minimum of **1 inch (25 mm)**.
 - c) Width not less than **[3 inches (75 mm)][blade width plus 2 inches (50 mm)]**.
 - 2) Blades: Hollow, airfoil shape; constructed of **[galvanized steel][Type 304 stainless steel][Type 316L stainless steel]**, minimum **0.06 inch (1.6 mm)** thick.
 - a) Width not to exceed **[6 inches (150 mm)][8 inches (200 mm)]**.
 - b) Length not to exceed **[36 inches (900 mm)][48 inches (1200 mm)][60 inches (1500 mm)]**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached EPDM or extruded silicone.
 - b) Jams: Stainless steel, double compression type.
 - 4) Axles: **0.5- or 0.75-inch- (13- or 19-mm-)** diameter **[plated][Type 304 stainless][or][Type 316 stainless]** steel, mechanically attached to blades **[and continuous from end to end]**.
 - 5) Bearings:
 - a) Stainless steel sleeve type mounted in frame.
 - b) Where blade axles are installed in vertical position, provide thrust bearings.
 - 6) Linkage:
 - a) Face linkage exposed to airstream.
 - b) Constructed of **[plated steel][Type 304 stainless steel][or][Type 316 stainless steel]**.
 - c) Hardware: **[Type 304][or][Type 316]** stainless steel.
 - 7) Locking Regulator:

- a) Stainless steel standoff with locking regulator mounted to frame in an accessible location for manual adjustment of damper blades.

EE. Smoke Dampers:

1. General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.
2. Rectangular Smoke Dampers with Aluminum Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 5) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.
 - e. Performance:
 - 1) Leakage: In accordance with UL 555S, Class 1.
 - 2) Pressure Drop: **0.05 inch wg (12.5 Pa) at 1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **250 deg F (121 deg C)**.
 - 5) Pressure Rating: **8.0 inches wg (2000 Pa)**.
 - f. Certification: NRTL listed and labeled in accordance with UL 555S, Class 1.
 - g. Construction:
 - 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.07 inch (1.8 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.
 - 2) Blades:

- a) Hollow, extruded airfoil shape.
 - b) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.07 inch (1.8 mm)** thick.
 - c) Width not to exceed **6 inches (150 mm)**.
 - d) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone.
 - b) Jams: Stainless steel, compression type.
 - 4) Axles: **0.5-inch- (13-mm-)** diameter **[plated][or][stainless]** steel, mechanically attached to blades.
 - 5) Bearings:
 - a) Molded synthetic or stainless steel sleeve mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
 - 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.
3. Rectangular Smoke Dampers with Galvanized-Steel Blades:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.
 - e. Performance:
 - 1) Leakage: In accordance with UL 555S, Class 1.
 - 2) Pressure Drop: **0.07 inch wg (17.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **250 deg F (121 deg C)**.

-
- 5) Pressure Rating: **8.0 inches wg (2000 Pa)**.
 - f. Certification: NRTL listed and labeled in accordance with UL 555S, Class 1.
 - g. Construction:
 - 1) Frame:
 - a) Material: Galvanized steel, minimum **0.06 inch (1.6 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.
 - 2) Blades:
 - a) Hollow, airfoil shape.
 - b) Material: Galvanized steel, minimum **0.06 inch (1.6 mm)** thick.
 - c) Width not to exceed **6 inches (150 mm)**.
 - d) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone.
 - b) Jambs: Stainless steel, compression type.
 - 4) Bearings:
 - a) Stainless steel sleeve type mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
 - 5) Linkage:
 - a) Concealed in frame.
 - b) Constructed of galvanized steel.
 - c) Hardware: Steel with corrosion-resistant finish.
 - h. Actuator:
 - 1) Type: Electric, with electrical characteristics compatible with field power supply.
 - 2) Action: **[See Drawings][modulating][or][two position]**.
 - 3) Control Signal: Individual damper assemblies with multiple actuators shall be factory wired to operate in unison from a single control signal.
 - 4) Fail Position: Closed or open, as indicated on Drawings.
 - 5) Mounting on Damper: External.
 - 6) Quantity: Provide each damper assembly with least number of actuators possible for application.
 - 7) Speed of Response:
 - a) Damper blade operation shall have a controlled movement of at least 5 seconds when travelling from open to close to reduce the potential for damage to duct system and connected equipment.
 - b) Damper closure shall not be instantaneous under any condition.
 - c) Operating time for completion of 90-degree damper travel, from open to close, or from close to open, shall not exceed the more stringent of the following: NFPA references indicated, governing codes, **[15 seconds]<Insert time>**.

i. Blade Position Switches:

- 1) Provide damper assemblies with limit switches to provide remote indication of damper blade positions.
- 2) Provide separate limit switches for remote indication of damper blade open position and damper blade closed position.
- 3) Actuators equipped with remote position indication as an integral part of actuator is acceptable in lieu of separate limit switches only if actuator with integral remote position indication is NRTL listed in accordance with UL 555S.

FF. Duct Silencers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Dynasonics]**
 - b. **[IAC Acoustics]**
 - c. **[Price Industries Limited]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **[Vibro-Acoustics]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dynasonics]**
 - b. **[IAC Acoustics]**
 - c. **[Price Industries Limited]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **[Vibro-Acoustics]**
 - f. **<Insert manufacturer's name>**
3. Duct Silencer Sourcing Option: In lieu of sourcing duct silencers from a specialty duct silencer manufacturer, air-handling unit manufacturer has option to furnish in-house silencers that achieve equal or better performance while complying with other requirements indicated.
 - a. Full-height duct silencers baffles shall span from floor to roof of air-handling unit air tunnel and consist of multiple baffles aligned to fill the entire cross-sectional area of air-handling unit air tunnel. In this alternative, the air-handling unit casing shall serve as the duct silencer casing.
4. General: Air-handling unit manufacturer shall furnish and install duct silencers and associated support structures inside air-handling units where indicated on Drawings.
 - a. Unless otherwise indicated on Drawings, select face area of silencers to fill the entire cross-sectional area of air-handling unit air tunnel.
 - b. Silencer Type: **[Dissipative][Reactive (packless)][Type, either dissipative or reactive (packless), indicated on Drawings]**.
 - c. Factory fabricated.
 - d. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50; ASTM E84.
 - e. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in

ASHRAE 62.1.

5. Ratings and Performance:
 - a. Duct silencer manufacturer shall publish performance for dynamic insertion loss (DIL), self-noise power levels, and airflow static pressure loss based on results of performance testing indicated.
 - b. Duct silencer manufacturer shall test duct silencers in accordance with ASTM E477 in a qualified nationally recognized independent testing laboratory or manufacturer's National Voluntary Lab Accreditation Program accredited laboratory.
 - 1) Conduct tests with air flowing through duct silencers at not less than three different flow rates and with no airflow.
 - 2) Test methods shall eliminate effects due to end reflection, vibration, flanking transmission, and standing waves in the test chamber.
 - c. DIL is not less than values indicated on Drawings.
 - d. Silencer self-generated noise shall not increase system sound level.
 - e. Static pressure loss not to exceed values indicated on Drawings.
 - f. Structural Performance:
 - 1) Design casing for differential air pressure of **8 inches wg (2000 Pa)** between.
 - 2) Reinforce duct silencer casing to limit deflection to 1/200 of span.
6. Construction: Fabricate rectangular silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for individual unit assemblies.
 - a. Casing:
 - 1) Unless otherwise indicated, construct outer casing in accordance with ASHRAE and SMACNA standards for construction of high-pressure rectangular ductwork.
 - 2) Casing seams and joints shall be lock formed and mastic filled, or continuously welded.
 - 3) Materials and Thicknesses, Aluminum, ASTM B209 (ASTM B209M) Alloy 3003-1114, Smooth Finish:
 - a) Outer Casing: Solid, minimum **[0.040 inch (1.0 mm)][0.063 inch (1.6 mm)]<Insert dimension>** thick.
 - b) Baffles: Perforated, minimum **[0.032 inch (0.8 mm)][0.040 inch (1.0 mm)]<Insert dimension>** thick for sizes through **[24 inches (600 mm)]<Insert dimension>** tall and **[0.040 inch (1.0 mm)][0.063 inch (1.6 mm)]<Insert dimension>** thick for larger sizes.
 - 4) Materials and Thicknesses, Galvanized Steel, ASTM A653/A653M, G60 (Z180) or G90 (Z275) Finish:
 - a) Outer Casing: Solid, minimum **[20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness>** thick.
 - b) Baffles: Perforated, minimum **[24 gauge (0.7 mm)][26 gauge (0.5 mm)]<Insert thickness>** for sizes through **[24 inches (600 mm)]<Insert dimension>** tall and **[20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness>** for larger sizes.
 - 5) Materials and Thicknesses, Stainless Steel, ASTM A240/A240M or ASTM

A480/A480M:

- a) Outer Casing: Solid, minimum [20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness> thick.
 - b) Baffles: Perforated, minimum [24 gauge (0.6 mm)][26 gauge (0.5 mm)]<Insert thickness> for sizes through [24 inches (600 mm)]<Insert dimension> tall and [20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness> for larger sizes.
- 6) Duct Silencer Material Applications:
- a) Exhaust Air, General: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - b) Exhaust Air, Hazardous: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - c) Mixed Air: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - d) Outdoor Air: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 304 stainless steel].
 - e) Return Air: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - f) Supply Air: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - g) <Insert material application>.
- b. Dissipative-Type Duct Silencer Fill Materials:
- 1) Inert, vermin-proof, and moisture-proof inorganic mineral or glass fiber of a density sufficient to obtain the acoustic performance indicated. Fiber-free fill materials are an acceptable alternative to fiber fill materials if complying with other requirements.
 - 2) Pack fill under not less than [5]<Insert number> percent compression.
 - 3) Fill material and coverings shall not exceed the following values when tested in accordance with ASTM E84, NFPA 255, and UL 723:
 - a) Flame-Spread Index: 25.
 - b) Smoke-Developed Index: 50.
 - c) Fuel Contribution: 20.
 - 4) Protective Coverings for Fiber Fill Materials:
 - a) Except for silencers used in exhaust applications completely cover silencer fiber fill materials with a protective covering, such as a tightly woven fiberglass fabric, to prevent particle contamination of airstream without degrading silencer acoustical performance.
 - b) For silencers located in airstreams filtered by absolute filters and where located in potentially hazardous exhaust airstreams, enclose the fiber fill material in a polymer sheeting to prevent contaminating air stream without impacting air cleanliness and hygiene. Offset polymer sheeting with honeycomb standoff to prevent polymer sheeting from coming in direct contact with perforated baffles.
- c. Reactive-Type (Packless) Duct Silencer Baffles: Controlled impedance membranes and broadly tuned resonators without absorptive fill material.
- d. Removable Baffles: Design and construct baffles to be easily removable for purposes of cleaning and replacement.

7. Factory Assembly:

- a. Install duct silencers in correct direction with respect to airflow.
- b. Manufacturer's written installation instructions shall not be compromised.
- c. Seal penetrations through duct silencer baffles using a sealant.
- d. Install duct silencers with baffles oriented in the vertical position.
- e. Duct silencer banks consisting of multiple individual duct silencers shall be as follows:
 - 1) Structurally reinforced to support loading and limit deflection to 1/200 of span.
 - 2) Provided with a continuous nosing to cover all joints of adjoining duct silencers. Nosing shall be constructed of same material as duct silencers and attached by friction fit, crimping, or button punch.
 - 3) Fastened together using **[zinc-plated][or][stainless]** steel sheet metal screws that are spaced at not more than **[6 inches (150 mm)]<Insert dimension>** apart, starting at corners.

8. Cleaning:

- a. After assembly, clean duct silencers with HEPA-filtered vacuum machines and then wipe all surfaces with a cleaning agent, using clean rags.

GG. Antimicrobial Ultraviolet (UV) Lamp Systems:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Ultraviolet]**
 - b. **[Steril-Aire, Inc.]**
 - c. **[UV Resources]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Ultraviolet]**
 - b. **[Steril-Aire, Inc.]**
 - c. **[UV Resources]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain UV lamp systems from single source from single manufacturer.
4. Description: UV-C lamp system consisting of power supply, wiring, lamp(s), plug(s), and holder(s) used for ultraviolet germicidal irradiation (UVGI) of cooling coil and condensate drain pan.
 - a. Factory assembled and engineered by a qualified design professional.
5. Certification: NRTL listed and labeled in accordance with UL 153, UL 1598, and UL 1995; UL Category Code ABQK; HVAC accessories; air-duct mounted.
6. Performance:
 - a. Operating Conditions: Suitable for operation in extreme conditions of the airstream encountered.

- 1) Relative humidity range not less than 5 to 100 percent.
 - 2) Temperature range not less than [34 to 158 deg F (1 to 70 deg C)]<Insert temperature range>.
 - 3) Velocity range not less than [0 to 600 fpm (0 to 3 m/s)]<Insert velocity range>.
 - b. Irradiation Intensity:
 - 1) Install sufficient quantity of UV-C lamps to provide an average irradiation intensity of [500][1000][2000]<Insert value> microwatts/sq. cm over coil face and exposed surfaces of drain pan.
 - 2) Install sufficient quantity of UVGI fixtures to provide an average irradiation intensity indicated on the Drawings.
 - 3) Submit calculations indicating high, low, and average irradiation intensity level across coil face area and drain pan.
 - 4) Take irradiation intensity measurements of factory assembly before air-handling unit shipment to determine results and confirm compliance with requirements. Document and submit measurement results confirming compliance.
 - 5) Intensity calculations shall be based on an average output over a lamp life of [9000]<Insert number> hours and account for light output degradation over the lamp life.
 - c. Lamp Life: Minimum of [9000]<Insert number> hours.
 - d. Light Output Degradation: Reduction in light output shall not exceed [15][20]<Insert number> percent of initial lamp output over the rated lamp life.
7. Construction:
- a. Lamps:
 - 1) Type: High output, hot cathode; non-ozone producing.
 - 2) Output: UV-C energy, primarily at the 254-nm wavelength with a 360-degree energy distribution.
 - 3) Protective Sleeve: Hermetically sealed to provide protection against lamp breakage and to ensure that lamp contents from a broken lamp are contained.
 - 4) Labeling: Lamp wattage and model number visibly printed on all lamps.
 - 5) Mercury Content: Less than 8 Mg of mercury in each lamp.
 - 6) Lamp Sourcing: Commercially sourced from more than one manufacturer for future replacement. Proprietary lamps available from only one manufacturer are unacceptable.
 - b. Lamp Holders:
 - 1) UV- and moisture-resistant materials designed to connect the lamp to the plug and ensure a watertight connection.
 - 2) Adjustable positioning.
 - c. Wiring Loom: UV-C-resistant jacket materials with internal aluminum/Mylar shield.
 - 1) Conduit: Loom covered with NRTL-listed flexible metal conduit, aluminum or stainless steel.
 - d. Power Supply: NRTL listed, single phase, 120 or 277 V ac as indicated, with a programmed rapid start.
 - 1) Power Factor: High power factor, Class P, Sound Rated A, Type 1 Outdoor, and with inherent thermal protection and without polychlorinated biphenyl.



- 2) Wiring Harness: Plug and play.
 - 3) Electrical Connection: Single electrical connection[**with service disconnect**].
 - e. Enclosures: NEMA 250, [Type 1][Type 4] constructed of [painted carbon steel][stainless steel]<Insert material>.
8. Air-Handling Unit Factory Assembly:
- a. Install UV-C lamp systems in accordance with manufacturer's written instructions.
 - b. Location: Install UV-C lamp system array [immediately downstream of cooling coil bottom drain pan][at locations indicated on Drawings]<Insert location within air-handling unit>.
 - c. UV-C Lamp System Support Assembly: [Aluminum][or][300 series grade stainless steel] framework rigidly attached to air-handling unit casing and adequately braced to provide ridge support of UV-C lamp systems that will not move or damage when leaned on or bumped into by operators.
 - d. Service Access: Lamps shall be easily replaceable from inside the air-handling unit.
 - 1) Install access door(s) with window to access UV light. Treat each window and test to confirm UV emitted through the window is below the threshold limits of NIOSH and ACGIH.
 - 2) If adequate space is unavailable inside air-handling unit, install UV-C lamp systems on a slide out rail to allow lamp replacement from one exterior side of air-handling unit.
 - e. Factory wire UV-C lamp systems internally and terminate at a disconnecting switch on the exterior of the air-handling unit casing.
 - 1) Switch to include a lock-out/tag-out feature.
 - 2) In addition to disconnecting switch, provide each access door accessible to UV-C lamp systems with a position limit switch wired into UV-C lamp systems power circuit to de-energize power to UV-C lamp systems when door is opened.
 - f. Install a caution nameplate at each UV-C lamp systems disconnecting switch that reads: "DANGER, UV LIGHTS - Turn off before entering."
 - g. Protection from UV Damage: Materials in direct or indirect (reflected) contact with UV shall be tested and certified as UV tolerant. Any material not certified shall be completely shielded from UV using a certified UV-tolerant material such as metal. UV tolerance shall be capable of performing intended duty for a minimum of [20]<Insert number> years.
 - h. Shipping: Remove UV-C lamps after factory testing; package and ship UV-C lamps in protective containers for field installation.
 - 1) Label exterior of enclosures with detailed description of container contents, including air-handling unit designation.
 - 2) Ship UV-C lamps for each air-handling unit in separate containers.
9. UV-C Lamp System Irradiance Monitoring:
- a. Sourcing: Furnished by UV-C lamp system manufacturer with UV-C lamp systems.
 - b. General: UVGI monitoring consisting of sensor(s) and controller to measure and locally display UV output irradiance in [absolute output (microwatts/sq. cm)][and][user-defined percentage of relative output]
 - c. Measurement Range: Suitable for highest measured irradiance encountered by application, but not less than [10,000][20,000]<Insert value> microwatts/sq. cm.
 - d. NIST traceable calibration.

- e. Remote Monitoring Signal: 4- to 20-mA output signal for remote monitoring.
10. UV-C Lamp System Status Monitoring:
- a. Sourcing: Furnished by UV-C lamp system manufacturer with UV-C lamp systems.
 - b. Monitors operating status of UV-C lamps by measuring change in electrical current.
 - c. On/off status of lamps displayed by LED lights on face of local display unit.
 - d. Remote Monitoring Signal: On/off status relays for remote monitoring.

HH. Heat Wheels:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Innergy Tech, Inc.]**
 - b. **[SEMCO, LLC; part of FlaktGroup]**
 - c. **[Thermotech Enterprises, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Innergy Tech, Inc.]**
 - b. **[SEMCO, LLC; part of FlaktGroup]**
 - c. **[Thermotech Enterprises, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain heat wheels from single source from single manufacturer.
4. Performance:
 - a. Heat wheels shall be engineered by manufacturer to provide a highly reliable, low-maintenance product for use under continuous operation over an extended operating period of not less than **[20][25]<Insert number>** years. Provide supporting documentation if requested to show how features of product design comply with performance indicated.
 - b. Products with ratings that exceed indicated pressure drop, fall short of sensible and latent recovery performance indicated, or transfer contaminants in excess of requirements indicated are unacceptable and should not be submitted for review and approval.
 - c. Fully-assembled and -installed heat wheel shall be suitable for use in air systems that supply air to tenant occupied space and shall comply with NFPA 90A and governing building codes.
5. Testing and Certification:
 - a. Thermal Performance: Certification by a qualified independent testing organization documenting the following:
 - 1) Sensible and latent recovery efficiencies conducted in accordance with ASHRAE 84 with results presented in accordance with ASHRAE 84 and AHRI 1060 (I-P) and AHRI 1061 (SI).
 - 2) Sensible, latent, and pressure loss performance over a range of operating points as required by ASHRAE 84 and specifically for actual airflow conditions required by Project.

- b. Cross Contamination: Cross-contamination performance reports to validate compliance with requirements indicated.
 - 1) Independent test report shall document desiccant-coated transfer media exhibits [3][or][4] Angstrom behavior and does not transfer pollutants typically encountered in indoor air environment having room operations and functions indicated.
 - 2) Testing shall be performed in a test facility complying with ASHRAE 84 for tracer gas testing.
 - 3) Challenge gases used for testing shall include chemicals that represent contaminants typically encountered and include at least the following: acetaldehyde, methanol, methyl isobutyl ketone, propane, and xylene <Insert contaminate>.
 - c. Flame and Smoke: NRTL test report listing flame-spread index and smoke-developed index of media when tested in accordance with ASTM E84 to comply with requirements indicated.
 - d. Microbial Resistance: Test report documenting ability of wheel faces and transfer media to actively limit microbial growth.
 - 1) Testing completed by a qualified research institution or testing laboratory using common live bacterial cultures to document antimicrobial performance with 95 percent mortality effectiveness.
 - e. Corrosion Resistance: Test report summarizing acid resistance effectiveness of media face coating completed in accordance with ASTM corrosion-test methodologies.
6. Rotors:
- a. Construct rotor media of aluminum base material precoated with a desiccant before forming into honeycomb media structure consisting of circular spiral layers.
 - b. Aluminum base material shall be at least [0.0015 inch (0.0381 mm)]<Insert dimension> thick before coating.
 - c. Media layers shall be joined together using adhesive to bond between flat and corrugated media layers.
 - d. Media Coating:
 - 1) Coat media surfaces with a non-migrating solid adsorbent desiccant layer before forming into the structure to ensure that all surfaces are coated.
 - 2) Desiccant coating shall be inorganic and use a [3][or][4] Angstrom molecular sieve to achieve desired [3][or][4] Angstrom selectivity, excluding contaminants larger than [3][or][4] Angstroms while effectively transferring water vapor.
 - 3) In addition to desiccant coating applied to aluminum substrate, cover two faces of rotor with a two-part polymer coating specifically chosen for chemical resistance and corrosion protection. Coating shall be selected to provide life expectancy indicated when exposed to airstreams encountered.
 - 4) Media exposed to airstream shall exhibit effective antimicrobial action to protect against development and spread of microbial contaminants.
 - 5) Rotor media with applied coatings and adhesive shall have a flame-spread index of [0]<Insert value> and a smoke-developed index of [5]<Insert value> when tested in accordance with ASTM E84.
 - e. Media depth shall be determined by heat wheel manufacturer to achieve performance indicated.
 - f. Media shall not transfer pollutants typically encountered in an indoor air environment having room operations and functions indicated.
 - g. Media shall be cleanable without degrading performance over time.

- h. Dry particles up to 800 microns shall pass freely through the media.
 - i. Provide segmented rotor media to allow for field installation and replacement of one section at a time without requiring side access. Removal and replacement shall be made while facing rotor media face.
 - j. Rotor media shall be held in place by a rigid structural spoke system made of extruded aluminum.
 - k. Coat exposed surfaces of aluminum spoke system for corrosion protection.
 - l. Rotor structural spoke system shall be designed and manufactured to provide for field installation of media without possibility of media deformation or misfit.
 - m. Media shall be secured within structural spoke system by mechanical means, relying on a formed friction fit without use of adhesives or silicone.
 - n. Rotors that cannot be installed in air-handling units as a single complete factory assembly coming from heat wheel manufacturer shall be remotely assembled by trained factory service personnel that are employed by heat wheel manufacturer.
7. Purge Sector:
- a. Factory-set, field-adjustable purge sector designed to limit cross contamination to less than **[0.04]<Insert number>** percent of that of exhaust airstream concentration into supply airstream.
 - b. Factory-set, field-adjustable purge sector designed to eliminate cross contamination of exhaust airstream into supply airstream.
8. Seals:
- a. Maintenance-free "non-contact" type to eliminate wear, excessive drag, and resulting added horsepower required for motor drive system, while still being capable of resisting high-pressure differences.
 - b. Equip rotor with labyrinth seals, which at no time shall make contact with any rotating surface of rotor face.
 - 1) Seals shall be field adjustable and set to within factory-specified tolerances.
 - 2) Provide multi-pass seals with four labyrinth stages for optimum performance or alternative design with documented test results showing comparable performance.
 - c. Seal shall be secured to housing either by an extruded-aluminum strip with adjustment slots for fastening bolts to the casing frame or by using adjustable clips. Clips shall be made of stainless steel or other noncorrosive material to resist corrosion and possible damage to transfer media.
9. Shafts:
- a. Shaft supporting rotor between bearings shall be one piece, solid steel, accurately turned, ground, polished, and ring gauged for accuracy.
 - b. Machine and polish shaft within bearing contact area to comply with bearing manufacturer's written recommended tolerances.
 - c. Use a dial indicator to inspect shafts for roundness and straightness.
 - d. Coat exposed surfaces of shaft with a corrosion-inhibitive coating.
 - e. Shaft shall be machined to provide a shoulder against bearings for a positive locked position to eliminate any lateral movement of rotor due to axial bearing loads.
10. Bearings:
- a. Support rotor shaft by two pillow block **[tapered roller]** bearings designed for an ABMA 11 L-10 life of at least **[200,000][1,000,000]** hours.
 - b. Bearings shall be maintainable and replaceable without removal of rotor from its casing or

- media from spoke support system.
 - c. Grease fittings for each bearing shall be easily accessible and within view of bearing.
 - d. Reverse Rotation: Clutch bearing and extended shaft, or equivalent alternative, to prevent reverse rotation and ensure that wheel can only rotate in direction commensurate with effective purge operation.
11. Frame and Housing:
- a. Design frame to limit deflection of rotor due to air pressure loss to less than **[0.03125 inch (0.79375 mm)]<Insert deflection>**, **[as measured at the outer radius, during maximum rated airflow condition]** when exposed to a wheel pressure differential of **[25]<Insert number>** percent above design conditions.
 - b. Construct rigid frame of welded structural **[aluminum][galvanized steel][painted steel][or][stainless steel]**.
 - c. Designed and manufactured in one, two, or more sections as required by application to provide a rigid structure, when completely assembled, capable of supporting rotor.
 - 1) For horizontal airflow applications, support rotor at each end only with no additional support under center.
 - 2) For vertical airflow applications, provide one additional bottom center support.
 - 3) Clearly mark each section of multiple section units for easy installation.
 - d. Construct housing of **[galvanized-steel][painted steel][aluminum][or][stainless steel]** formed sheets designed to prevent corrosion.
 - e. Housing shall be reinforced as required to provide a solid mounting surface of peripheral and radial seals, to maintain a fixed distance between rotor surface and any housing part.
 - f. There shall be no special requirement to provide air-handling unit casing side access for future rotor removal and service. All rotor service shall be performed from inside air-handling unit at face of rotor.
 - g. Requirements for Painted Frame and Housing:
 - 1) Comply with painting manufacturer's written preparation and application requirements.
 - 2) Treat galvanized steel that is not phosphatized with a phosphate rinse to ensure that paint adheres.
 - 3) Apply rust-inhibiting primer before applying finishing coats.
 - 4) Apply multiple coats to achieve dry film thickness required for protection indicated.
 - 5) Finish coat color to be **[manufacturer's standard]<Insert color>**.
 - 6) Painted products shall have no deterioration when subjected to the following:
 - a) Salt spray test in accordance with ASTM B117 with 5 percent salt solution fog at 95 deg F for a period of **[500][1000][2000]<Insert number>** hours.
 - b) Acid-resistance test in accordance with ASTM D3260 with 15-minute exposure to 10 percent hydrochloric acid at room temperature.
12. Motor and Drive Assembly:
- a. Motor Enclosure: Totally enclosed.
 - b. Motor nameplate horsepower shall exceed maximum load of driven assembly.
 - c. Multiple belt-drive assembly shall be automatically tensioned and arranged to eliminate any side-to-side movements and slippage.
 - d. Motor and drive assembly shall be easily accessible and visible for inspection and maintenance.
 - e. Drive assembly, except motor, shall have a life expectancy of **[45,000][90,000]<Insert number>** hours.

13. Variable-Frequency Controller:
 - a. Variable-speed control of rotor through a variable-frequency controller.
 - b. Digital programming with a manual-speed adjustment on the front face of controller.
 - c. Rotor drive system shall allow for a turndown ratio of 80:1 (20 to 0.25 rpm).
 - d. Controller with switchable control either locally on front of controller or remotely by a control system.
 - e. Controller with a motor-rated disconnect switch or circuit breaker having a withstanding rating greater than that required by field electrical power system, but not less than **[42,000][65,000]<Insert value> A**.
 - f. Controller mounted in a NEMA 250, **[Type 1][Type 4][Type 4X][or][Type 12]** enclosure.
14. Rotation Sensor: Proximity-type rotation sensor and target to provide **[rotational speed (rpm) analog signal and]** wheel stop digital alarm signal for interface to remote-control system.
15. Monitoring and Control:
 - a. Single-Source Responsibility: Heat wheel manufacturer shall provide a complete monitoring and control package for heat wheel with controller, local display, operator interface, sensors, switches, transmitters, accessories, components, devices, and programming for a complete and operating heat wheel to ensure that responsibility for heat wheel and its operation resides with one source.
 - b. Enclosure:
 - 1) House controller and control devices in a NEMA 250, **[Type 1][Type 4][Type 4X][or][Type 12]** enclosure.
 - 2) Enclosure with LCD screen to allow viewing and changing parameters.
 - 3) Enclosure with full front face hinged door and lockable handle.
 - 4) Air-handling unit manufacturer shall mount enclosure of outside of air-handling unit casing in vicinity of heat wheel.
 - c. DDC with the following:
 - 1) Conversion of temperature and relative humidity readings into grains, dew point, and enthalpy.
 - 2) Calculation and reporting of real-time unit effectiveness.
 - 3) Calculation and reporting of accumulation of energy (Btu) recovered over time.
 - 4) With user input of energy costs, calculation and accumulation of dollars saved over time.
 - 5) An alarm output if wheel is not rotating and not rotating in correct direction.
 - 6) Programming for integration of enthalpy-based summer-winter change over, frost prevention and supply temperature control such that they also function correctly as the wheel speed is modulated.
 - 7) Communications and data transfer for remote monitoring and control through ASHRAE 135 (BACnet) interface.
 - 8) Option to achieve conversion and calculations indicated is for heat wheel manufacturer to employ building controls provider, to provide a field-installed DDC with LCD to be mounted directly adjacent to heat wheel manufacturer monitoring and control enclosure.
 - d. Four, field-mounted, high-precision dry-bulb temperature and either wet-bulb temperature or humidity sensors shall be provided by heat wheel manufacturer to air-handling unit manufacturer for factory mounting in accordance with heat wheel manufacturer's written instructions to measure dry-bulb temperature and either wet-bulb temperature or humidity at each of four energy wheel airstreams.
 - 1) Sensors shall be wired to controller or controller expander board located within

enclosure.

- e. Wheel Rotation: Rotation detector module to detect a rotating wheel, and correct direction of rotation[**and speed**].
- f. Active Monitoring and Control of Purge: Manufacturer's standard method to ensure that proper purge operation is maintained actively in response to changes in system airflows and pressures that normally occurs with a variable-volume system and where pressure changes appreciably due to filter loading and damper modulation.

16. Air-Handling Unit Factory Assembly:

- a. Internal Access: Provide each heat wheel with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
- b. Removal and Replacement: Each heat wheel shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
- c. Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
- d. Supports for Heat Wheel:
 - 1) Construct a freestanding and self-supporting structural framework to support each heat wheel individually from and independent of adjacent heat wheels.
 - 2) Construct frame work from aluminum[, **galvanized-steel,**] or stainless steel[**structural shapes**].
- e. Comply with heat wheel manufacturer's written installation instructions.

II. Fixed Plate Heat Exchangers:

1. Fixed Plate Sensible Heat Exchangers:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Heatex, Inc.]**
 - 2) **[Innergy Tech, Inc.]**
 - 3) **[Klingenburg]**
 - 4) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Heatex, Inc.]**
 - 2) **[Innergy Tech, Inc.]**
 - 3) **[Klingenburg]**
 - 4) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain heat exchangers from single source from single manufacturer.
- d. Description: A device for purpose of transferring only sensible energy from one airstream to another with no moving parts. Design may incorporate parallel, cross- or counterflow construction or a combination of these to achieve the energy transfer.
- e. Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.

- 1) Maximum Pressure Differential: Suitable for maximum [6 inches wg (1500 Pa)]<Insert pressure>.
- 2) Maximum Temperature: Suitable for maximum [194 deg F (90 deg C)]<Insert temperature>.
- f. Casing: [Aluminum][Galvanized steel]<Insert material>.
- g. Plates: Evenly spaced, sealed, and arranged for [counter][cross] airflow.
 - 1) Plate Material: [Embossed aluminum][Stainless steel][High-density plastic]<Insert material>.
 - 2) Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for heat exchangers requiring a corrosion-resistant coating.
 - 3) Aluminum Plate Coating: [None][Epoxy]<Insert coating>. See Drawings for heat exchangers requiring a corrosion-resistant coating.
2. Fixed Plate Total Heat Exchangers:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [CORE Energy Recovery Solutions]
 - 2) [Dais Analytic Corporation]
 - 3) [Innergy Tech, Inc.]
 - 4) <Insert manufacturer's name>
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [CORE Energy Recovery Solutions]
 - 2) [Dais Analytic Corporation]
 - 3) [Innergy Tech, Inc.]
 - 4) <Insert manufacturer's name>
 - c. Source Limitations: Obtain heat exchangers from single source from single manufacturer.
 - d. Description: A device for purpose of transferring total energy (sensible and latent) from one airstream to another with no moving parts. Design may incorporate parallel, counterflow construction to achieve the energy transfer.
 - e. Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.
 - 1) Maximum Pressure Differential: Suitable for maximum [6 inches wg (1500 Pa)]<Insert pressure>.
 - 2) Maximum Temperature: Suitable for maximum [194 deg F (90 deg C)]<Insert temperature>.
 - f. Casing: [Aluminum][Galvanized steel]<Insert material>.
 - g. Plates: Evenly spaced, sealed, and arranged for counter airflow.
 - 1) Plate Material and Coating: Chemically treated paper, or polymer on [aluminum]<Insert material>, with selective hydroscopicity, moisture permeability, and gas barrier properties.
3. Air-Handling Unit Factory Assembly:

- a. Internal Access: Provide each fixed plate heat exchanger with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
- b. Removal and Replacement: Each fixed plate heat exchanger shall be independently removable and replaceable through a removable access panel or door installed in air-handling unit casing.
- c. Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
- d. Supports for Fixed Plate Heat Exchanger:
 - 1) Construct a freestanding and self-supporting structural framework to support heat exchangers.
 - 2) Construct frame work from aluminum[, **galvanized-steel,**] or stainless steel[**structural shapes**].
- e. Comply with fixed plate heat exchanger manufacturer's written installation instructions.

JJ. Heat Pipe Heat Exchangers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Engineered Air]**
 - b. **[Heat Pipe Technology, Inc.]**
 - c. **[Innergy Tech, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Engineered Air]**
 - b. **[Heat Pipe Technology, Inc.]**
 - c. **[Innergy Tech, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain heat exchangers from single source from single manufacturer.
4. Description: Air-to-air energy recovery heat exchanger employing tubes charged with a fluid for purpose of transferring sensible energy from one airstream to another through the vaporization of fluid.
5. Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.
6. Certification: Rated[, **listed and labeled**] in accordance with AHRI 1060 (I-P) and AHRI 1061 (SI).[**NRTL listed in accordance with UL 207.**]
7. Casing and Tube Sheets: **[Galvanized-steel][or][stainless steel]** flanged casing minimum **[16 gauge (1.6 mm)]<Insert thickness>** thick, with airtight **[single][double][foam-filled double]** partition between exhaust and supply airstreams.
8. Fluid in Sealed Tubes: Selected by heat pipe heat exchanger manufacturer and classified as Safety Group A1 in accordance with ASHRAE 34.
9. Tubes:
 - a. Tube Diameter: Selected by heat pipe heat exchanger manufacturer; not less than nominal **1/2 inch (13 mm)** and not more than nominal **1 inch (25 mm)** in diameter.
 - b. Tube Material: **[Aluminum][or][copper]<Insert material>**; minimum thickness required for

- fluid pressure and temperature encountered.
 - c. Number of Tube Rows: As required by performance; not to exceed [8]<Insert number>.
- 10. Fins: **[Aluminum][or][copper]<Insert material>**.
 - a. Fin Configuration: **[Extruded][plate][or][spiral]**.
 - b. Fin Spacing: As required by performance; not to exceed **12 fins per inch (2.1 mm)**.
 - c. Fin and Tube Bond: **[Mechanical expanded into collared fins and tube sheets][Silver brazed]**.
- 11. Coating: **[None][Flexible epoxy polymer E-coating][Baked phenolic]<Insert coating>**; apply to supply and exhaust.
- 12. Control:
 - a. Integral plenum containing heat pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.
 - b. Pivot center of bottom of heat pipe coil on shaft and bearings to tilt coil. Include tilt controls with electronic controller, electric actuator and linkage, thermostats, sensors, and polyester-fabric-coated flexible connector for automatic supply temperature regulation, summer/winter changeover, and frost protection.
- 13. Air-Handling Unit Factory Assembly:
 - a. Internal Access: Provide each heat pipe heat exchanger with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Removal and Replacement: Each heat pipe heat exchanger shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - c. Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
 - d. Supports for Heat Pipe Heat Exchanger:
 - 1) Construct a freestanding and self-supporting structural framework to support each heat pipe heat exchangers individually from and independent of adjacent heat pipe heat exchangers.
 - 2) Construct frame work from aluminum[, **galvanized-steel,**] or stainless steel[**structural shapes**].
 - e. Comply with heat pipe heat exchanger manufacturer's written installation instructions.

KK. Air Blenders:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Blender Products, Inc.]**
 - b. **[Kees, Inc]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Blender Products, Inc.]**

- b. **[Kees, Inc]**
- c. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain blenders from single source from single manufacturer.
- 4. Description: Static air mixing devices fabricated in assemblies consisting of multidirectional vanes that are designed to reduce stratification of multiple mixed airstreams and improve uniformity of the air tunnel velocity profile located downstream of air mixer.
- 5. Performance:
 - a. Certification: Documented performance verified by tests performed by an independent agency **[or][factory tests witnessed by a professional engineer that is not a company employee]**.
 - b. Mixing: Uniform mixed airstream within **[6 deg F (3 deg C)]<Insert temperature>** of the theoretical average temperature of two or more airstreams.
 - c. Indicated on Drawings.
- 6. Construction:
 - a. Configuration: Indicated on Drawings.
 - b. Material: **[Aluminum][galvanized steel][Type 304 stainless steel][or][Type 316 stainless steel]**.
 - c. Thickness: **[0.080 inch (2.06 mm)][0.125 inch (3.18 mm)]<Insert dimension>**.
 - d. Attachment: Integral mounting flange for attachment to mounting substrate.
 - e. Welding: Stitch or continuous welds. Filler metals matched to welded materials.
 - f. Hardware: **[Stainless][Zinc-plated carbon]** steel.
 - g. OEM Factory Assembly: Single-piece assembly for sizes through **96 inches (2400 mm)**. For larger sizes, air mixers shall be fabricated in two pieces, bolted together to ensure proper fit and alignment and then disassembled for shipment.
 - h. Finish: **[Anodized]<Insert requirements>**.
- 7. Air-Handling Unit Factory Assembly:
 - a. Internal Access: Provide each air mixer with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Install air mixer assemblies in an internal separating wall reinforced to limit deflection to **[L/200]<Insert value>** when subjected to a horizontal force of **[200 lb (900 N)]<Insert value>** at any point on the air mixer assembly.
 - c. Blank-off and seal assembly to prevent leakage and air bypass around air mixer.
 - d. Operating Clearance: Maintain upstream and downstream operating clearances in accordance with manufacturer's written installation requirements.

LL. Close-Coupled, In-Line Centrifugal Pumps:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Armstrong International, Inc]**
 - b. **[Bell & Gossett; a Xylem brand]**
 - c. **[GRUNDFOS CBS Inc.]**
 - d. **[Taco Comfort Solutions]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Armstrong International, Inc]**
 - b. **[Bell & Gossett; a Xylem brand]**
 - c. **[GRUNDFOS CBS Inc.]**
 - d. **[Taco Comfort Solutions]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain pumps from single source from single manufacturer.
 4. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.
 5. Pump Construction:
 - a. Casing: Radially split, cast iron, with threaded gauge tapings at inlet and outlet[, **replaceable bronze wear rings,**] and threaded **[companion-flange][or][union-end]** connections.
 - b. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
 - c. Pump Shaft: **[Steel, with copper-alloy shaft sleeve][Stainless steel]**.
 - d. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and **[Buna-N][EPT][FKM]<Insert material>** bellows and gasket. Include water slinger on shaft between motor and seal.
 6. Motor: Rigidly mounted to pump casing.
 - a. Enclosure: **[ODP][or][TEFC][totally enclosed, nonventilated]**.
 - b. Enclosure Materials: **[Cast iron][or][rolled steel]**.
 - c. Motor Bearings: **[Permanently lubricated][or][grease-lubricated]** ball bearings.
 - d. Efficiency: NEMA Premium efficient.
 - e. NEMA Design: **<Insert designation>**.
 - f. Service Factor: **[1.15]<Insert value>**.

MM. Air-Handling Unit Factory Drain Piping and Piping Insulation:

1. General:
 - a. Air-handling unit manufacturer to factory install piping inside air-handling units.
 - b. If more than one material is listed, material selection is by air-handling unit manufacturer.
2. Aluminum Piping:
 - a. Pipe: Aluminum ASTM B241/B241M, Grade 1061, Temper T6, seamless longitudinal joints with beveled or plain ends; and wall thickness as indicated under applications.
 - b. Fittings: Cast aluminum, ASTM B26/B26M, Grade 356, Temper T6, ASME B16.1 Class 150; threaded ends.
 - c. Flanges: Cast aluminum, ASTM B26/B26M, Grade 356, Temper T6, ASME B16.1, Class 150 including bolts, nuts, washers, and gaskets of the following end connections and facings:
 - 1) Threaded end connections for threaded joints, welding-neck with butt-joint for welded joints, and blinds for use with flanged joints requiring close-off.
 - d. Unions: Cast aluminum, ASTM B26/B26M, Grade 356, Temper T6, hexagonal-stock body;

female NPT threaded ends.

3. Copper Tubing:

- a. Tubing: Drawn-temper, **[ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88M, Type C)][or][Type DWV in accordance with ASTM B306]**.
- b. Fittings: Wrought-copper and copper alloy, ASME B16.22, pressure fittings.
- c. Unions: Cast-copper-alloy, MSS SP-123, hexagonal-stock body; female NPT threaded ends
- d. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux in accordance with ASTM B813.

4. Stainless Steel Piping:

- a. Pipe: ASME B36.19/ASME B36.19M, stainless steel ASTM A312/A312M, with beveled or plain ends; seamless **[or welded]** longitudinal joints, Grade TP316L, and wall thickness as indicated under applications.
- b. Fittings, Threaded: MSS SP-114, Class 150, stainless steel ASTM A351/A351M, Grade CF8M.
- c. Fittings, Welded: ASME B16.9, stainless steel ASTM A403/A403M, Grade WP316L, seamless, wall thickness to match adjoining pipe.
- d. Flanges: Stainless steel ASTM A182/A182M, Grade F316L, ASME B16.5, Class 150 including bolts, nuts, washers, and gaskets of the following material group, end connections, and facings:
 - 1) Material Group: 2.2.
 - 2) Threaded end connections for threaded joints, welding-neck with butt-joint for welded joints, and blinds for use with flanged joints requiring close-off.
- e. Unions: MSS SP-114, Class 150, stainless steel ASTM A351/A351M, Grade CF8M; female NPT threaded ends.

5. Floor Drain Piping:

- a. **[Schedule 40]<Insert pipe schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or][copper tube with soldered threaded male adapters]**.
- b. Factory install a dedicated drain pipe for each floor drain and extend pipe to access side of air-handling unit.
 - 1) Terminate pipe with a threaded pipe cap **[3 inches (75 mm)]<Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.
 - 2) Pipe size to match size of floor drain connection.

6. Fan Drain Piping:

- a. **[Schedule 40]<Insert pipe schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or][copper tube with soldered threaded male adapters]**.
- b. Factory install a dedicated drain pipe for each housed centrifugal fan with a drain connection and extend pipe to access side of air-handling unit.
 - 1) Terminate pipe with a threaded pipe cap **[3 inches (75 mm)]<Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.
 - 2) Install a twin sphere **[EPDM][or][neoprene]** pipe connector in the pipe between the

- fan connection and the pipe penetration through the air-handling unit casing.
- 3) Pipe size to match size of fan drain connection.
- 4) Install a threaded union or thread-on flange in drain pipe at connection to fan.

7. Drain Pan Piping:

- a. **[Schedule 40]<Insert pipe schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or][copper tube with soldered threaded male adapters]**.
- b. Factory install drain piping for drain pan(s). Install a dedicated drain pipe for each drain pan serving different air-handling unit internal components. Where multiple drain pans serve like components interconnect drain piping to a single drain pipe for field connection.
 - 1) Where interconnecting cooling coil condensate drain pans from upstream and downstream sides of cooling coil, provide pipe with a water seal trap configured to prevent air bypass.
 - 2) Terminate pipe with a threaded pipe cap **[3 inches (75 mm)]<Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.
 - 3) Drain pipe size to match size of drain pan connection.

8. Piping Insulation:

- a. Factory insulate bottom cooling coil drain pan pipe with **[1-inch- (25-mm-)]<Insert dimension>** thick, flexible elastomeric insulation where pipe is located under and outside of the air-handling unit casing but within the air-handling unit base.
- b. Factory insulate steam and steam condensate piping located inside of air-handling with **[2-inch- (25-mm-)]<Insert dimension>** thick, preformed mineral-fiber pipe insulation.
- c. Cover pipe insulation with a factory-applied aluminum or stainless steel jacket.

NN. Air-Handling Unit Factory Hydronic Piping and Piping Insulation:

1. Chilled-Water Piping:

- a. Design Pressure and Temperature: **[See Drawings]<Insert pressure and temperature>**.
- b. Pipe: ASME B36.10M, carbon steel ASTM A53/A53M, with beveled or plain ends; **[electric resistance weld][or][seamless]** longitudinal joints, Grade B; standard weight.
- c. Fittings, Threaded: Malleable iron, ASME B16.3; **[Class 150][or][Class 300]**.
- d. Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234/A234M, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.
- e. Flanges, Weld: Weld-neck, forged carbon steel, ASME B16.5; **[Class 150][or][Class 300]**.
- f. Unions, Threaded: Malleable iron, ASME B16.39; **[Class 150][or][Class 300]**.
- g. Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304][or][Type 316]** stainless steel with openings not larger than **0.032 inch (0.8 mm)**; **[Class 125][or][Class 250]**.
- h. Valves:
 - 1) Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, extended stem, and stationary outer sleeve to protect insulation vapor seal.
 - 2) Butterfly: Lugged body; MSS SP-67; cast-iron, ductile-iron, or cast-steel body; stainless steel disk, EPDM seat, and **[lever][or][gear]** operator; rated for system pressure, but not less than **[250-psig (1724-kPa)]<Insert value>** bi-directional dead-end shutoff with downstream flange removed.
 - 3) Check: Globe-style, MSS SP-125; cast-iron ASTM A126 body, stainless steel spring, and bronze seat; **[Class 125][or][Class 250]**.
 - 4) **<Insert valve type>**.

- i. Vents: Cast-iron body, stainless steel float, **NPS 1/2 (DN 15)** or larger inlet connection.
 - j. Flow Meters: In-line electromagnetic type with integral display and accuracy within 3 percent of reading.
 - k. Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A][or][Grade B]** accuracy; metal case with nominal **[4-1/2-inch (114-mm)][6-inch (152-mm)]<Insert dimension>** shatter-resistant glass face and **NPS 1/2 (DN 15)** threaded brass connection.
 - l. Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded **NPS 1/2 (DN 15)** connection.
 - m. Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch (125-mm)]<Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.
 - n. Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.
 - 1) **NPS 2 (DN 50)** and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.
 - 2) Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.
 - 3) Gradually slope piping for venting and drainage.
 - 4) Include threaded drain connections and ball valves with threaded hose-end, cap, and chain at all low points in piping.
 - 5) Comply with requirements indicated on Drawings.
 - 6) Make connections to coils with a **[flange][or][union]**.
 - 7) Connect to each coil inlet with shutoff valve, test plug, **[strainer][pressure gauge][and][thermometer]**.
 - 8) Connect to each coil outlet with balancing valve, test plug, **[pressure gauge][thermometer][flow meter][and][shutoff valve]**.
 - 9) Connect each coil drain connection with a drain valve, which is full size of drain connection.
 - 10) Connect each coil vent connection with **[automatic][or][manual]** vent, which is full size of vent connection.
 - 11) Connect to each pump inlet with flange or union, shutoff valve, test plug, strainer **and pressure gauge**.
 - 12) Connect to each pump outlet with flange or union, check valve, balancing valve, test plug, **[pressure gauge][flow meter][and][shutoff valve]**.
 - 13) Include with each strainer a blowdown connection consisting of a nipple and threaded ball valve with threaded hose-end, cap, and chain.
2. Chilled-Water Piping Insulation and Identification:
- a. Insulation: Preformed, **[cellular glass][phenolic foam][or][flexible elastomeric]<Insert material>**; minimum **[2 inches (50 mm)]<Insert dimension>** thick.
 - b. Adhesive: Compatible with insulation material and recommended in writing by insulation manufacturer.
 - c. Jacket: **[None][ASJ][PVC, color selected by Architect, 20 mils (0.5 mm) thick][Aluminum, smooth, 0.020 inch (0.51 mm) thick]<Insert jacket>**.
 - d. Air-Handling Unit Factory Assembly: Continuously insulate and vapor seal piping system throughout its entire length. Insulate all surface capable of forming condensation.
 - 1) Install high-density insulation insert products, consisting of two 180-degree halves, at pipe hangers and supports. Material density sufficient to accommodate loading without deformation.
 - 2) Insulation thickness determined by air-handling unit manufacturer to comply with governing codes, ASHRAE/IES 90.1, and minimum thickness indicated and to prevent condensation.

- 3) Insulate piping system only after successful completion of pressure tests.
- 4) Install adhesive-backed acrylic identification labels indicating [pipe size]service and direction of flow at multiple locations sufficient for operators to easily follow the flow path. Each branch pipe should have at least one label.

3. Heating Water Piping:

- a. Design Pressure and Temperature: **[See Drawings]<Insert pressure and temperature>**.
- b. Pipe: ASME B36.10M, carbon steel ASTM A53/A53M, with beveled or plain ends; **[electric resistance weld][or][seamless]** longitudinal joints, Grade B; standard weight.
- c. Fittings, Threaded: Malleable iron, ASME B16.3; **[Class 150][or][Class 300]**.
- d. Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234/A234M, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.
- e. Flanges, Weld: Weld-neck, forged carbon steel, ASME B16.5; **[Class 150][or][Class 300]**.
- f. Unions, Threaded: Malleable iron, ASME B16.39; **[Class 150][or][Class 300]**.
- g. Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304][or][Type 316]** stainless steel with openings not larger than **0.032 inch (0.8 mm)**; **[Class 125][or][Class 250]**.
- h. Valves:
 - 1) Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, and extended stem.
 - 2) Butterfly: Lugged body; MSS SP-67; cast-iron, ductile-iron, or cast-steel body; stainless steel disk, EPDM seat, and **[lever][or][gear]** operator; rated for system pressure, but not less than **[250-psig (1724-kPa)]<Insert pressure>** bi-directional dead-end shutoff with downstream flange removed.
 - 3) Check: Globe-style, MSS SP-125; cast-iron ASTM A126 body, stainless steel spring, and bronze seat; **[Class 125][or][Class 250]**.
 - 4) **<Insert valve type>**.
- i. Vents: Cast-iron body, stainless steel float, **NPS 1/2 (DN 15)** or larger inlet connection.
- j. Flow Meters: In-line electromagnetic type with integral display and accuracy within 3 percent of reading.
- k. Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A][or][Grade B]** accuracy; metal case with nominal **[4-1/2-inch (114-mm)][6-inch (152-mm)]<Insert dimension>** shatter-resistant glass face and **NPS 1/2 (DN 15)** threaded brass connection.
- l. Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded **NPS 1/2 (DN 15)** connection.
- m. Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch (125-mm)]<Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.
- n. Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.
 - 1) **NPS 2 (DN 50)** and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.
 - 2) Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.
 - 3) Gradually slope piping for venting and drainage.
 - 4) Include threaded drain connections and ball valves with threaded hose-end, cap, and chain at all low points in piping.
 - 5) Comply with requirements indicated on Drawings.
 - 6) Make connections to coils with a **[flange][or][union]**.
 - 7) Connect to each coil inlet with shutoff valve, test plug, **[strainer][pressure gauge][and][thermometer]**.

- 8) Connect to each coil outlet with balancing valve, test plug, **[pressure gauge][thermometer][flow meter][and][shutoff valve]**.
- 9) Connect each coil drain connection with a drain valve, which is full size of drain connection.
- 10) Connect each coil vent connection with **[automatic][or][manual]** vent, which is full size of vent connection.
- 11) Connect to each pump inlet with flange or union, shutoff valve, test plug, strainer **and pressure gauge**.
- 12) Connect to each pump outlet with flange or union, check valve, balancing valve, test plug, **[pressure gauge][flow meter][and][shutoff valve]**.
- 13) Include each strainer with a blowdown connection consisting of a nipple and threaded ball valve with threaded hose-end, cap, and chain.

4. Heating Water Piping Insulation and Identification:

- a. Insulation: Preformed, **[cellular glass][mineral fiber][or][phenolic foam]<Insert material>**; minimum **[2 inches (50 mm)]<Insert dimension>** thick.
- b. Adhesive: Compatible with insulation material and recommended in writing by insulation manufacturer.
- c. Jacket: **[ASJ][PVC, color selected by Architect, 20 mils (0.5 mm) thick][Aluminum, smooth, 0.020 inch (0.51 mm) thick]<Insert jacket>**.
- d. Air-Handling Unit Factory Assembly: Continuously insulate and seal piping insulation system throughout its entire length.
 - 1) Install high-density insulation insert products, consisting of two 180-degree halves, at pipe hangers and supports. Material density sufficient to accommodate loading without deformation.
 - 2) Insulation thickness determined by air-handling unit manufacturer to comply with governing codes, ASHRAE/IES 90.1, and minimum thickness indicated and to prevent condensation.
 - 3) Insulate piping system only after successful completion of pressure tests.
 - 4) Install adhesive-backed acrylic identification labels indicating **[pipe size]** service and direction of flow at multiple locations sufficient for operators to easily follow the flow path. Each branch pipe should have at least one label.

5. Piping Hangers and Supports:

- a. Finish: Galvanized metallic coatings including pregalvanized, hot-dip galvanized, or electro-galvanized.
- b. Hangers: MSS-SP-58, Type 1.
- c. Supports: MSS-SP-58, Type 4, Type 24, or Type 37.
- d. Threaded Rods: Continuous-thread rod, nuts, and washer made of **[galvanized steel][or][stainless steel]<Insert material>**.
- e. Strut: MFMA-4, continuous slotted **[carbon steel][stainless steel, Type 304][stainless steel, Type 316][extruded-aluminum]<Insert material>** channel with intumed lips.
- f. Air-Handling Unit Factory Assembly:
 - 1) Ridgely support piping from internal structure in accordance with governing codes and MSS SP-58.

OO. Air-Handling Unit Factory Steam and Condensate Piping And Piping Insulation:

1. Steam Piping:

- a. Design Pressure and Temperature: **[See Drawings]<Insert pressure and temperature>**.

- b. Pipe: ASME B36.10M, carbon steel ASTM A53/A53M, with beveled or plain ends; **[electric resistance weld][or][seamless]** longitudinal joints, Grade B; standard weight.
- c. Fittings, Threaded: Cast iron, ASME B16.4; **[Class 125][or][Class 250]**.
- d. Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234/A234M, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.
- e. Flanges, Weld: Weld-neck, forged carbon steel, ASME B16.5; **[Class 150][or][Class 300]**.
- f. Unions, Threaded: MSS SP-83, Class 3000, ASTM A105/A105M.
- g. Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304][or][Type 316]** stainless steel with openings not larger than **0.032 inch (0.8 mm)**; **[Class 125][or][Class 250]**.
- h. Valves:
 - 1) Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, and extended stem.
 - 2) Check:
 - a) Bronze with Bronze Disc: MSS SP-80, Type 3; Class 150.
 - b) Iron with Metal Seats: MSS SP-71, Type I; **[Class 125][or][Class 250]**.
 - 3) Gate:
 - a) Bronze: **[MSS SP-80, Type 1][or][MSS SP-80, Type 2]**; Class 150.
 - b) Iron: MSS SP-70, Type I, **[NRS][OS & Y]**; **[Class 125][or][Class 250]**.
 - 4) Globe:
 - a) Bronze: MSS SP-80, Type 2; Class 150.
 - b) Iron: MSS SP-85, Type I; **[Class 125][or][Class 250]**.
- i. Flow Meters: Vortex-shedding type with integral display and accuracy within 5 percent of reading.
- j. Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A][or][Grade B]** accuracy; metal case with nominal **[4-1/2-inch (114-mm)][6-inch (152-mm)]<Insert dimension>** shatter-resistant glass face and **NPS 1/2 (DN 15)** threaded connection.
- k. Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded **NPS 1/2 (DN 15)** connection.
- l. Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch (125-mm)]<Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.
- m. Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.
 - 1) **NPS 2 (DN 50)** and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.
 - 2) Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.
 - 3) Gradually slope piping for venting and drainage at not less than 2 percent.
 - 4) Include threaded drain connections and ball valves with threaded hose-end, cap, and chain at all low points in piping.
 - 5) Comply with requirements indicated on Drawings.
 - 6) Make connections to coils **and humidifiers** with a **[flange][or][union]**.
 - 7) Connect to each coil inlet with shutoff valve, test plug, vacuum breaker, **[strainer][flow meter][pressure gauge][and][thermometer]**.
 - 8) Connect to each humidifier inlet with shutoff valve, test plug, vacuum breaker **[strainer][flow meter][pressure gauge][and][thermometer]**.

- 9) Include each strainer with a blowdown connection consisting of a nipple and threaded gate valve with threaded hose-end, cap, and chain.

2. Steam Condensate Piping:

- a. Design Pressure and Temperature: **[See Drawings]<Insert pressure and temperature>**.
- b. Pipe: ASME B36.10M, carbon steel ASTM A53/A53M, with beveled or plain ends; **[electric resistance weld][or][seamless]** longitudinal joints, Grade B; Schedule 80.
- c. Fittings, Threaded: Cast iron, ASME B16.4; **[Class 125][or][Class 250]**.
- d. Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234/A234M, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.
- e. Flanges, Weld: Weld-neck, forged carbon steel, ASME B16.5; **[Class 150][or][Class 300]**.
- f. Unions, Threaded: MSS SP-83, Class 3000, ASTM A105/A105M.
- g. Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304][or][Type 316]** stainless steel with openings not larger than **0.032 inch (0.8 mm)**; **[Class 125][or][Class 250]**.
- h. Steam Traps:
 - 1) Material: **[Cast iron][Stainless steel][Stainless steel, Grade 304][Stainless steel, Grade 316]**.
 - 2) Type: **[Inverted bucket][or][float and thermostatic]**.
 - 3) Capacity: Sized for a minimum of **[3]<Insert number>** times the maximum rated condensate flow at **[1/2-psig (3.4-kPa)]<Insert value>** differential pressure.
- i. Valves:
 - 1) Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, and extended stem.
 - 2) Check:
 - a) Bronze with Bronze Disc: MSS SP-80, Type 3; Class 150.
 - b) Iron with Metal Seats: MSS SP-71, Type I; **[Class 125][or][Class 250]**.
 - 3) Gate:
 - a) Bronze: **[MSS SP-80, Type 1][or][MSS SP-80, Type 2]**; Class 150.
 - b) Iron: MSS SP-70, Type I, **[NRS][OS & Y]**; **[Class 125][or][Class 250]**.
 - 4) Globe:
 - a) Bronze: MSS SP-80, Type 2; Class 150.
 - b) Iron: MSS SP-85, Type I; **[Class 125][or][Class 250]**.
- j. Vents: Cast-iron body, stainless steel float, **NPS 1/2 (DN 15)** or larger inlet connection.
- k. Flow Meters: In-line electromagnetic type with integral display and accuracy within 3 percent of reading.
- l. Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A][or][Grade B]** accuracy; metal case with nominal **[4-1/2-inch (114-mm)][6-inch (152-mm)]<Insert dimension>** shatter-resistant glass face and **NPS 1/2 (DN 15)** threaded brass connection
- m. Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded **NPS 1/2 (DN 15)** connection.
- n. Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch (125-mm)]<Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.

- o. Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.
 - 1) **NPS 2 (DN 50)** and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.
 - 2) Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.
 - 3) Gradually slope piping for venting and drainage at not less than 2 percent.
 - 4) Include threaded drain connections and valves with threaded hose-end, cap, and chain at all low points in piping.
 - 5) Comply with requirements indicated on Drawings.
 - 6) Make connections to coils [**and humidifiers**]with a [**flange**][or][union] .
 - 7) Connect to each coil outlet with strainer, steam trap, test plug, vent [**pressure gauge**][**thermometer**][**flow meter**][and][**shutoff valve**].
 - 8) Connect to each humidifier outlet with strainer, steam trap, test plug, [**pressure gauge**][**thermometer**][**flow meter**][and][**shutoff valve**].
 - 9) Connect each coil drain connection with a drain valve, which is full size of drain connection.
 - 10) Include each strainer with a blowdown connection consisting of a nipple and threaded ball valve with threaded hose-end, cap, and chain.
3. Steam and Condensate Piping Insulation:
 - a. Insulation: Preformed, [**cellular glass**][or][**mineral fiber**]**<Insert material>**; minimum [**3 inches (75 mm)**][**4 inches (100 mm)**][**5 inches (125 mm)**]**<Insert dimension>** thick.
 - b. Adhesive: Compatible with insulation material and recommended in writing by insulation manufacturer.
 - c. Jacket: [**ASJ**][**Aluminum, smooth, 0.020 inch (0.51 mm) thick**]**<Insert jacket>**.
 - d. Air-Handling Unit Factory Assembly: Continuously insulate and seal piping insulation system throughout its entire length.
 - 1) Install high-density insulation insert products, consisting of two 180-degree halves, at pipe hangers and supports. Material density sufficient to accommodate loading without deformation.
 - 2) Insulation thickness determined by air-handling unit manufacturer to comply with governing codes, ASHRAE/IES 90.1, and minimum thickness indicated and to prevent condensation.
 - 3) Insulate piping system only after successful completion of pressure tests.
 - 4) Install adhesive-backed acrylic identification labels indicating [**pipe size**]service and direction of flow at multiple locations sufficient for operators to easily follow the flow path. Each branch pipe should have at least one label.
4. Piping Supports:
 - a. Finish: Galvanized metallic coatings including pregalvanized, hot-dip galvanized, or electro-galvanized.
 - b. Hangers: MSS-SP-58, Type 1.
 - c. Supports: MSS-SP-58, Type 4, Type 24, or Type 37.
 - d. Threaded Rods: Continuous-thread rod, nuts, and washer made of [**galvanized steel**][or][**stainless steel**]**<Insert material>**.
 - e. Strut: MFMA-4, continuous slotted [**carbon steel**][**stainless steel, Type 304**][**stainless steel, Type 316**][**extruded-aluminum**]**<Insert material>** channel with inturned lips.
 - f. Air-Handling Unit Factory Assembly:
 - 1) Ridgely support piping from internal structure in accordance with governing codes and MSS SP-58.

PP. Drains:**1. Floor Drains:**

- a. Drain Body: Fabricate floor drain body of **NPS 4 (DN 100)** or larger aluminum or stainless pipe and weld a plate of same material to the bottom. Option to fabricate an aluminum or stainless steel rectangular box drain at least **4 by 4 inches (100 by 100 mm)** of material at least **0.1 inch (3 mm)** thick.
- b. Drain Connection: Weld a nominal **[NPS 2 (DN 50)]<Insert pipe size>** half coupling in side of drain body located within **1 inch (25 mm)** from bottom.
- c. Drain Cover: Perforated plate, at least **0.1 inch (3 mm)** thick, or grating, fabricated from aluminum or stainless steel. Drain cover shall be supported and secured in place by drain body, but not fastened to drain body with fasteners.
- d. Fluid Seal: **[Seal][Weld]** floor drain body to air-handling unit floor for a watertight installation.
- e. Mounting: Recess floor drain body into structural base. Top of floor drain to be slightly recessed below air-handling unit finished floor for unobstructed gravity flow from floor into drain.
- f. Application:
 - 1) Install floor drains in air-handling unit floors at locations indicated on Drawings.
 - 2) Install floor drains in air-handling unit floors of all sections.
 - 3) Install floor drains in air-handling unit floors of **[coil][coil and humidifier][coil, heat wheel, heat exchanger, humidifier][potentially wet]<Insert floor drain locations>** sections and associated access sections.

QQ. Factory-Assembled Electrical:

1. Factory install **[UV-C and switches],[service light fixtures and switches],[and][receptacles]** for each air-handling unit.
 - a. Locate in a convenient and field-accessible location.
 - b. Installation shall comply with NFPA 70.
 - c. Wire, Conduit, and Enclosures:
 - 1) Minimum Conduit Size: **[3/4 inch (20 mm)]<Insert dimension>**.
 - 2) Materials: **[Metal, with a corrosion-resistant finish][Aluminum or stainless steel][Stainless steel]**.
 - 3) Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware **[constructed of stainless steel]**.
 - 4) Conduit: Locate conduit inside the air-handling unit casing. Conduit installed on exterior of air-handling unit casing is unacceptable.
 - 5) Wire: Copper, rated for 600 V, solid wire for size **[No. 10 AWG]<Insert wire size>** and smaller and stranded wire for larger sizes.
 - 6) Minimum Wire Size: **[No. 12 AWG]<Insert wire size>**.
 - 7) Each circuit shall have a ground wire.
 - 8) Install wire in conduit.
 - d. Boxes, Conduit Outlet Bodies, and Enclosures:
 - 1) Located in Airstream: NEMA 250, **[Type 4][Type 4X][or][Type 12]<Insert Type>**.
 - 2) Located in Service Corridor: NEMA 250, **[Type 1][Type 4][or][Type 12]<Insert Type>**.
 - 3) Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R][Type 4][or][Type 4X]<Insert Type>**.

- e. Seals: Seal pathways to prevent air leakage between air-handling unit exterior and interior, and between internal component sections.
- f. UV-C Lamp System Applications: Wire all UV-C lamp systems located in the same air tunnel to a single circuit.
- g. Service Lighting Applications:
 - 1) Provide quantity of 20-A branch circuits required to power service light fixtures.
 - 2) For air-handling units consisting of multiple stacked tiers, provide separate circuits for top and bottom tiers of air-handling units.
 - 3) Factory install a **[main disconnect switch][field power junction box]** for interfacing air-handling power for service lighting with single-point field power wiring connection.
- h. Receptacle Applications:
 - 1) For air-handling units consisting of multiple stacked tiers, provide separate circuits for top and bottom tiers of air-handling units.
 - 2) Factory wire receptacles to a **[main disconnect switch][field power junction box]** for interfacing air-handling power for receptacles with a single-point field power wiring connection.
- 2. Main Disconnect Switches: Factory-install main disconnect switch mounted on air-handling unit casing exterior for interface of factory power wiring with field power wiring.
 - a. Specification Grade: "Heavy Duty Type"; "quick-make," "quick-break" construction.
 - b. Three pole, **[fused][or][nonfused]**.
 - c. 600 V rated.
 - d. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert value> A**.
 - e. Enclosure:
 - 1) Located in Service Corridor: NEMA 250, **[Type 1][Type 4][or][Type 12]<Insert Type>**.
 - 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R][Type 4][or][Type 4X]<Insert Type>**.
 - f. Operating handle shall be of box-mounted type that directly drives switch mechanism.
 - g. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
 - h. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
 - i. Include a solid neutral as required by authorities having jurisdiction.
 - j. Disconnect switch shall have a ground lug for ground wire termination.
 - k. Operating handle shall be lockable in open position.
 - l. Horsepower rated.
 - m. Feed through or double lugged.
- 3. Field Power Junction Box: Factory-install junction box with internal wire terminal block mounted on air-handling unit casing exterior for interface of factory power wiring with field power wiring.
- 4. Exterior Service Light Fixtures:
 - a. LED Luminaires for Outdoors:
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

-
- manufacturer's name; product name or designation>.**
 - 2) Finish: Selected by Architect from available finishes offered by manufacturer.
 - 3) Mounting: Wall.
 - 4) Intended for direct exposure in outdoor locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - 5) Light Color: **[4000][5000]** K.
 - 6) Light Output: **[3000][6000][8000]** lumens.
 - 7) Additional Protection: **[Vandal guard][or][wire guard]**.
 - 8) On/Off Operation: **[Local toggle switch][Photo cell with local override toggle switch]**.
 - b. Vaportight Fixtures:
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>.**
 - 2) Finish: Selected by Architect from available finishes offered by manufacturer.
 - 3) Mounting: Wall.
 - 4) Intended for direct exposure in outdoor locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - 5) Cast-aluminum housing and guard with heat-resistant, tempered, clear glass globe.
 - 6) Incandescent Lamps: **[150][200][300]** W.
 - 7) LED A21 Series Lamps:
 - a) Light Color: **[3000][5000]** K.
 - b) Light Output: **[1700]<Insert value>** lumens.
 - c. Application:
 - 1) Provide service light fixtures where indicated on Drawings.
 - 2) Provide one service light fixture on each side of air-handling unit with access doors. Position fixture at midpoint of most remote access doors.
 - 5. Interior Service Light Fixtures:
 - a. Fluorescent Luminaires:
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>.**
 - 2) Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - 3) High-impact, UV-stabilized, fiberglass-reinforced polyester housing; high-impact acrylic lens.
 - 4) Two, cool white, T **[5][5HO][8][8HO]** lamps; and an electronic ballast.
 - b. LED Luminaires:
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>.**
 - 2) Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - 3) High-impact, UV-stabilized fiberglass housing and acrylic lens.
 - 4) Light Color: **[3500][4000][5000]** K.
 - 5) Light Output: **[2000][3000][4000]** lumens.
 - 6) Driver: 1 percent dimming.

c. Vaportight Fixtures:

- 1) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>**.
- 2) Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
- 3) Cast-aluminum housing and guard with heat-resistant, tempered, clear glass globe.
- 4) Incandescent Lamps: **[150][200][300]** W.
- 5) LED A21 Series Lamps:
 - a) Light Color: **[3000][5000]** K.
 - b) Light Output: **[1700]<Insert value>** lumens.

d. Application:

- 1) Provide service light fixtures where indicated on Drawings.
- 2) Provide one service light fixture in each accessible section of air-handling units.
- 3) Provide one service light fixture in fan[, **coil**][**filter**]**<Insert section>** sections of air-handling units.

6. Toggle Switches for Service Light Fixtures:

- a. Single-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
- b. Two-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
- c. Three-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
- d. Four-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
- e. Lighted Single-Pole Switches, 120/277 V, 20 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.
 - 1) Description: Handle illuminated when switch is on.
- f. Toggle Switch Box and Cover: Mount toggle switch in a **[metal][cast-aluminum]** outlet box with **[cast-aluminum][or][stainless steel]** cover. Weatherproof where exposed to outdoors.
- g. Application:
 - 1) Factory install switching configuration (single, three way, or four way) required to operate a single service light fixture or group of service light fixtures from any access door that opens to respective service light fixtures.
 - 2) Factory install service light switches at locations indicated on Drawings.
 - 3) Factory install a single service light switch to switch all service light fixtures from a single location.
 - 4) Factory install a service light switch for each service light fixture or group of service light fixtures accessible from a single access door adjacent to the access door.
- h. Switches with Lighted Handles Applications: Lighted handle feature may be omitted where on/off status of internal lights can be viewed through an access door window.

7. Receptacles:

- a. Isolated-Ground Duplex Receptacles, 125 V, 20 A:
 - 1) Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.

- 2) Configuration: NEMA WD 6, Configuration 5-20R.
 - 3) Standards: Comply with UL 498 and FS W-C-596.
- b. Duplex GFCI Receptacles, 125 V, 20 A:
- 1) Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
 - 2) Configuration: NEMA WD 6, Configuration 5-20R.
 - 3) Type: Non-feed through.
 - 4) Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
- c. Receptacle Box and Cover: Mount receptacle in a **[metal][cast-aluminum]** outlet box with **[cast-aluminum][or][stainless steel]** cover. Weatherproof where exposed to outdoors.
- d. Applications: Factory install a receptacle in a convenient and field-accessible location on air-handling unit exterior of casing **[at locations indicated on Drawings][near access doors accessing fans][near access doors accessing electric heaters and fans][near access doors accessing energy wheels and fans][near access doors accessing electric heaters, energy wheels and fans]<Insert locations>**.
8. Power Supply to Fan Motors:
- a. As indicated on Drawings.
 - b. Factory install a **[disconnect switch][junction box][motor controller][variable-frequency controller]** for each fan motor.
 - 1) Locate in a convenient and field-accessible location on unit exterior.
 - 2) Installation shall comply with NFPA 70.
 - 3) Wire, Conduit, and Enclosures:
 - a) Minimum Conduit Size: **[3/4 inch (20 mm)]<Insert dimension>**.
 - b) Materials: Metal, corrosion resistant **[and constructed of stainless steel]**.
 - c) Motor Termination: Flexible conduit, NRTL listed, not to exceed **36 inches (900 mm)** long.
 - d) Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware **constructed of stainless steel**.
 - e) Wire: Copper, rated for 600 V, solid wire for size **[No. 10 AWG]<Insert wire size>** and smaller and stranded wire for larger sizes.
 - f) Minimum Wire Size: **[No. 12 AWG]<Insert wire size>**.
 - g) Each circuit shall have a ground wire.
 - h) Install wire in conduit.
 - 4) Boxes, Conduit Outlet Boxes, and Enclosures:
 - a) Located in Airstream: NEMA 250, **[Type 4][Type 4X][or][Type 12]<Insert Type>**.
 - b) Located in Service Corridor: NEMA 250, **[Type 1][Type 4][or][Type 12]<Insert Type>**.
 - c) Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R][Type 4][or][Type 4X]<Insert Type>**.
9. Disconnect Switches:
- a. Specification Grade: "Heavy Duty Type"; "quick-make," "quick-break" construction.
 - b. Three pole, **[fused][or][nonfused]**.
 - c. 600 V rated.

- d. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than [42,000][65,000]<Insert value> A.
 - e. Enclosure:
 - 1) Located in Service Corridor: NEMA 250, [Type 1][Type 4][or][Type 12]<Insert Type>.
 - 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, [Type 3R][Type 4][or][Type 4X]<Insert Type>.
 - f. Operating handle shall be of box-mounted type that directly drives switch mechanism.
 - g. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
 - h. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
 - i. Include a solid neutral as required by authorities having jurisdiction.
 - j. Disconnect switch shall have a ground lug for ground wire termination.
 - k. Operating handle shall be lockable in open position.
 - l. Horsepower rated.
 - m. Feed through or double lugged.
10. Motor Field Power Junction Box:
- a. Provide junction box with internal wire terminal block mounted on unit exterior for interface with field power wiring.
 - 1) Provide for each motor not installed with a factory disconnect or controller with integral disconnect.
 - b. Factory install internal wiring and conduit to motor.
11. Motor Controllers:
- a. NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.
 - b. Configured for control of single- or multispeed motors as indicated.
 - c. Enclosure: Hinged full-front access door with lock and key.
 - 1) Located in Service Corridor: NEMA 250, [Type 1][Type 4][or][Type 12]<Insert Type>.
 - 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, [Type 3R][Type 4][or][Type 4X]<Insert Type>.
 - d. Externally Operated Disconnect: [Door-Interlocked,][Fused disconnect switch][Nonfused disconnect switch][Circuit breaker] with lockable handle.
 - e. Short-Circuit Current Rating: As required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
 - f. Hand-Off-Auto Switch: Mounted on face of enclosure.
 - g. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
 - h. Control Relays: Time-delay relays.
 - i. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
 - j. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
 - k. Number-of-Starts Counter: Numerical readout on face of enclosure.
12. Variable-Frequency Controllers:

- a. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
- b. Enclosure: Unit mounted, with hinged full-front access door with lock and key.
 - 1) Located in Service Corridor: NEMA 250, [Type 1][Type 4][or][Type 12]<Insert Type>.
 - 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, [Type 3R][Type 4][or][Type 4X]<Insert Type>.
- c. Externally Operated Disconnect: [Door-Interlocked,][Fused disconnect switch][Nonfused disconnect switch][Circuit breaker] with lockable handle.
- d. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
- e. Technology: Pulse-width-modulation (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
- f. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
- g. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
- h. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
- i. Operating Requirements:
 - 1) Input AC Voltage Tolerance: [10]<Insert number> percent.
 - 2) Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - 3) Capable of driving full motor load, without derating.
 - 4) Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 5) Minimum Displacement Primary-Side Power Factor: 95 percent.
 - 6) Overload Capability: 1.05 times the full-load current for 7 seconds.
 - 7) Starting Torque: As required by fan and motor drive assembly.
 - 8) Speed Regulation: 1 percent.
 - 9) Speed Range: 10:1 speed range.
 - 10) To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
 - 11) Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
- j. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
- k. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or need for replacement:
 - 1) Surge suppression.
 - 2) Loss of input signal protection.
 - 3) Critical frequency rejection.
 - 4) Overtemperature.
 - 5) Short circuit at controller output.
 - 6) Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
 - 7) Open circuit at controller output.
 - 8) Input undervoltage.
 - 9) Input overvoltage.
 - 10) Loss of input phase.
 - 11) Reverse phase.

- 12) AC line switching transients.
 - 13) Instantaneous overload, line to line or line to ground.
 - 14) Sustained overload exceeding 100 percent of controller rated current.
 - 15) Starting a rotating motor.
 - 16) **<Insert features>**.
- l. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
- m. Automatic Reset and Restart:
- 1) Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
 - 2) Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
- n. Visual Indication: On face of controller; indicating the following conditions:
- 1) Power on.
 - 2) Run.
 - 3) Overcurrent and overvoltage.
 - 4) Motor speed (percentage).
 - 5) Various faults with alarm status.
 - 6) Input kilovolt amperes.
 - 7) Power factor.
 - 8) Input kilowatts and kilowatt-hours.
 - 9) Three-phase input and output voltage.
 - 10) Three-phase input and output current.
 - 11) Output frequency.
 - 12) Elapsed operating time (hours).
 - 13) Diagnostic and service parameters.
 - 14) **<Insert conditions>**.
- o. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
- p. Hardwired Control Signal Interface: A minimum of **[two]<Insert number>** analog inputs (0 to 10 V or 0/4 to 20 mA) and **[four]<Insert number>** programmable digital inputs.
- q. Remote Communication Interface: **[ASHRAE 135 BACnet MS/TP][ASHRAE 135 BACnet IP]<Insert requirements>**.
- r. Line Conditioning:
- 1) Input line conditioning.
 - 2) Output filtering.
 - 3) EMI/RFI filtering.
- s. Bypass Controller:
- 1) Bypass Controller/Variable-Frequency Controller Selector Switch: Include manual selector switch on face of enclosure for local operator control of preferred controller.
 - 2) Bypass Mode: **[Manual operation only][Field-selectable automatic or manual]**.
 - a) In automatic mode, include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.
 - 3) Type: Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.
 - 4) Arrangement: Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while

- operating fan motor through bypass controller for safe servicing of variable-frequency controller.
- 5) Enclosure: Install bypass controller in same enclosure as variable-frequency controller.
- 6) Remote Monitoring: Include control relay for remote indication of bypass controller operation.

RR. Factory-Assembled Controls:

1. General:

- a. Air-handling unit manufacturer shall furnish and factory install control instruments, control power circuit, control transformers, power supplies, wiring, tubing, raceways, and control panels.
- b. Provide for a single-point field connection to [120][277]-V electrical power for all factory-installed controls. Terminate power connection with a toggle switch mounted in control panel.
- c. Control panel shall serve as field tie-in point for all electric damper actuators, and control instruments located within air-handling unit. Controls for control dampers, control valves and instruments installed in ductwork and piping are not included as part of air-handling unit factory-installed controls.
- d. Control instruments shall be installed in accordance with manufacturer's written instructions.
- e. Control panel shall house flow, moisture, pressure and temperature transmitters, transformers, dc voltage power supplies, and wiring terminal strip.
- f. Carbon dioxide transmitters shall be mounted on air-handling unit casing exterior with sensor port exposed to the airstream.
- g. Factory install the following control instruments:
 - 1) Flow station and flow transmitter for each fan.
 - 2) Pressure sensors (inlet and discharge) and one combination pressure differential transmitter, switch, and controller for each filter bank installed in the air-handling unit.
 - 3) Pressure sensor and combination pressure differential transmitter, switch, and controller at the inlet of each fan.
 - 4) Pressure sensor and combination pressure differential transmitter, switch, and controller at the discharge of each fan.
 - 5) Carbon dioxide sensor/transmitters at locations indicated on Drawings.
 - 6) Moisture and temperature sensors and transmitters at locations indicated on Drawings.
 - 7) Temperature switches at locations indicated on Drawings.
 - 8) Control instruments indicated on Drawings.
 - 9) <Insert requirements>.

2. Wire and Cable:

- a. Single Conductor Control Wiring above 24 V:
 - 1) Wire size shall be at least No. 16 AWG.
 - 2) Conductor shall be 7/24 soft annealed copper stranding with a **2- to 2-1/2-inch (50- to 65-mm)** lay.
 - 3) Conductor insulation shall be 600 V, Type THWN or Type THHN, 90 deg C in accordance with UL 83.
 - 4) Conductor colors shall be black (hot), white (neutral), and green (ground).

- b. Single Twisted Shielded Instrumentation Cable above 24 V:
 - 1) Wire size shall be minimum No. 18 AWG.
 - 2) Conductors shall be a twisted, 7/24 soft annealed copper stranding with a **2- to 2-1/2-inch (50- to 65-mm)** lay.
 - 3) Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
 - 4) Shielding shall be 100 percent 0.35/0.5-mil aluminum/mylar tape, helically applied with 25 percent overlap, and aluminum side in with a No. 18 AWG-7/26 tinned copper drain wire.
 - 5) Outer jacket insulation shall have a 600-V, 90 deg C rating and shall be Type TC cable.
 - 6) For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red, and white.
- c. Single Twisted Shielded Instrumentation Cable 24 V and Lower:
 - 1) Wire size shall be minimum No. 18 AWG.
 - 2) Conductors shall be a twisted, 7/24 soft annealed copper stranding with a **2- to 2-1/2-inch (50- to 65-mm)** lay.
 - 3) Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
 - 4) Shielding shall be 100 percent 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with a No. 20-22 AWG tinned copper drain wire.
 - 5) Outer jacket insulation shall have a 300-V, 105 deg C rating and shall be Type PLTC cable.
 - 6) For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red, and white.
- d. Wire and Cable Installation:
 - 1) Comply with manufacturer's written instructions and NFPA 70.
 - 2) Grounding shall be in accordance with IEEE C2. Ground wire shall be copper. Demonstrate ground resistance.
 - 3) Wiring and cables shall be installed in conduit. Exposed wire and cable are unacceptable.
 - 4) Wire and cables may be grouped in a common raceway, except do not group wires and cables from different voltages.
 - 5) Install control wiring in a separate conduit from power wiring.
 - 6) Wiring shall be continuous from terminal to terminal without splices.
 - 7) Do not install low-voltage wire and cable closer than **[12 inches (300 mm)]<Insert distance>** from line voltage electrical power wire and cables. Provide an installation free of EMI.
 - 8) Use insulated spade lugs for wiring connection to screw terminals.
 - 9) Use shielded cable to transmitters.
 - 10) Terminate wiring and cables within a control panel, within instrument housing, or in a junction box. Clamp the cable over the jacket, in the junction box. Individual conductors in the stripped section of cable shall be slack between clamping point and terminal block.
 - 11) Terminate wire and cable in control panel with terminal blocks.
 - 12) Identify each wire and cable on each end and at each terminal with a number coded identification tag. Each wire and cable conductor shall have a unique tag.
 - 13) Perform continuity and meager testing on wiring and cable.

3. Raceways:

- a. Conduit:
 - 1) Install wiring and cable in conduit.
 - 2) Minimum Conduit Size: [1/2 inch (13 mm)][3/4 inch (20 mm)]<Insert dimension>.
 - 3) Materials: Metal, corrosion resistant[and constructed of stainless steel].
 - 4) Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware[constructed of stainless steel].
 - 5) Terminations to Actuators and Instruments: Flexible conduit, NRTL listed, not to exceed 24 inches (600 mm) long.
- b. Boxes, Conduit Outlet Boxes, and Enclosures:
 - 1) Located in Airstream: NEMA 250, [Type 4][Type 4X][or][Type 12]<Insert Type>.
 - 2) Located in Service Corridor: NEMA 250, [Type 1][Type 4][or][Type 12]<Insert Type>.
 - 3) Located on Exterior of Air-handling Unit Casing: NEMA 250, [Type 4][or][Type 4X]<Insert Type>.
- c. Seals: Seal pathways to prevent air leakage between air-handling unit exterior and interior, and between internal component sections.
- d. Conduit Installation:
 - 1) Conduit shall be continuous and secured in a manner that is electrically continuous throughout.
 - 2) Secure threaded conduit entering a cabinet, box or enclosure with a locknut on outside and on inside, such that conduit system is electrically continuous throughout.
 - a) Install a metal bushing with insulated throat on inside.
 - b) Locknuts designed to bite into metal, or on inside of enclosure and shall have a grounding wedge lug under locknut.
 - 3) Conduit box connectors for conduit entering enclosures shall be insulated throat type.
 - 4) Connect conduit with watertight sealing locknuts that are suitable for wet applications.
 - 5) Offset conduits where they enter surface-mounted equipment and panels.
 - 6) Neatly loop and lace wiring installed in panels and other enclosures.
 - 7) Seal conduit runs to prevent the circulation of air by installing seal fittings.
 - 8) Install conduit inside of air-handling unit casing. Wiring and conduit running on exterior of air-handling unit casing is unacceptable.
- 4. Tubing and Fittings:
 - a. Products in this paragraph are intended for use with the following:
 - 1) Main air and signal air to pneumatically controlled instruments, actuators, and other control devices and accessories.
 - 2) Signal air between pressure instruments, such as sensors, switches, transmitters, controllers, and accessories.
 - b. Copper Tubing:
 - 1) Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties in accordance with ASTM B75/B75M.
 - 2) Performance, dimensions, weight and tolerance in accordance with ASTM B280.

- 3) Diameter, as required by application, not less than nominal **0.25 inch (6 mm)**.
- 4) Wall thickness, as required by application, but not less than **0.030 inch (0.8 mm)**.
- c. Copper Tubing Fittings: Brass, compression type.
- d. Polyethylene Tubing:
 - 1) Fire-resistant black virgin polyethylene in accordance with ASTM D1248, Type 1, Class C and Grade 5.
 - 2) Tubing shall comply with stress crack test in accordance with ASTM D1693.
 - 3) Diameter, as required by application, of not less than nominal **0.25 inch (6 mm)**.
- e. Polyethylene Tubing Fittings: Brass, compression type.
- f. Stainless Steel Tubing:
 - 1) Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale.
 - 2) Chemical and physical properties in accordance with ASTM A269/A269M.
 - 3) Diameter, as required by application, of not less than nominal **0.25 inch (6 mm)**.
 - 4) Wall thickness, as required by application, but not less than **0.035 inch (0.9 mm)**.
 - 5) Furnish stainless steel tubing in **20-foot (6-mm)** straight random lengths.
- g. Stainless Steel Tubing Connectors and Fittings:
 - 1) Connectors and fittings shall be stainless steel, with stainless steel collets, flareless type.
 - 2) Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.
- h. Tubing Installation:
 - 1) Use **[copper][or][stainless steel]** tubing except use fire-resistant polyethylene for tubing located in control panels.
 - 2) Run tubing parallel to, and at right angles to, casing.
 - 3) Route multiple runs of tubing in neat parallel lines.
 - 4) Support tubing as follows:
 - a) Support metal tubing with hangers, clips, and tube trays.
 - b) Do not use tapes for mounting tubing.
 - c) Place a support within **1 foot (0.3 m)** of each change in direction and each branch take off.
 - d) Spacing between supports shall not exceed **[60 inches (1500 mm)]<Insert distance>**.
 - 5) Tubing shall not interfere with access to dampers and equipment or obstruct passageways of any kind.
 - 6) Provide vibration loops in tubing when connecting to equipment that might vibrate.
 - 7) Where joining or mating dissimilar metals where galvanic action could occur, provide dielectric isolation.
 - 8) Make tubing bends with a bending tool. Hard bends, or wrinkled or flattened bends are unacceptable.
 - 9) Install tubing fitting make-up in accordance with manufacturer's written instructions.
 - 10) Do not make tubing connections to a fitting before completing make-up connection.
 - 11) Properly align tubing with fitting. Springing tube into position can result in excessive stress on both tubing and fitting with possible resulting leaks.
 - 12) Do not install fittings close to a bend. Length of straight tubing, not deformed by bending is required for a proper connection.

- 13) Check tubing for correct diameter and wall thickness. Tube ends shall be cut square and deburred. Exercise care during cutting to keep tubing round.
- 14) Wrap threads of fittings with a single wrap of PTFE tape.
- 15) Install tubing with extreme care to keep foreign matter out. Keep open ends of tubing plugged to keep out dust, dirt, and moisture.
- 16) Mark each tube on each end with a number-coded identification. Each tube shall have a unique number.
- 17) Test tubing as follows:
 - a) Test for leaks and obstructions. Disconnect each tubing run before test is run, and blow out trash, condensate, and other foreign material with compressed air.
 - b) After foreign matter is expelled and the line is free from obstructions, plug the far end of tubing run.
 - c) Connect a pressure source to the near end with a needle valve between air supply and tubing run. Only commercially pure dry compressed air or nitrogen as distributed in gas cylinders is acceptable for this test.

5. Control Panels:

- a. Design control panels for grouping and protecting various electric, and/or electronic components.
- b. NRTL listed in accordance with UL 50 or UL 50E.
- c. Enclosure:
 - 1) Located in Service Corridor: NEMA 250, **[Type 1][Type 4][or][Type 12]<Insert Type>**.
 - 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 4][or][Type 4X]<Insert Type>**.
- d. Construct enclosure of steel, not less than the following:
- e. Enclosure Size Less Than 24 inches (600 mm): **[0.053 inch (1.35 mm)][or][0.067 inch (1.7 mm)]** thick.
- f. Enclosure size 24 inches (600 mm) and Larger: **[0.067 inch (1.7 mm)][or][0.093 inch (2.36 mm)]** thick.
- g. Support front panel using a non-removable piano hinge that runs entire height of cabinet.
- h. Each panel shall not exceed height of air-handling unit casing and **72 inches (1800 mm)** high.
- i. Secure front panel with a key locking mechanism. Common key the locks, and provide one pair of keys per panel.
- j. Front panel with a window of size so all instrument displays are visible with door closed.
- k. Mount panels on exterior wall of air-handling unit casing on primary access side of unit.
- l. Paint control panel exterior with enamel at least 5 mils thick. Color of panel exterior and interior shall be white.
- m. Include panel field power supply with a toggle-type switch located at entrance inside panel to disconnect power.
- n. Include panel with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
- o. Size control panel to provide at least 25 percent spare area on subpanel.
- p. Arrange control panel so similar type equipment is grouped together, and a barrier is installed between electrical and electronic equipment.
- q. Interior ambient temperature shall not rise above manufacturer's recommended maximum operating temperature for products installed within the panels. Provide filtered louvers and circulating fans, when necessary, to meet criteria.

- r. Panel shall serve as a central tie-in point for control devices such as remote sensors, transmitters, power supplies, and transformers.
 - 1) Factory install internal wiring in compliance with specified standards.
 - 2) Terminate wiring using an electric terminal strip with heavy-duty terminal blocks.
 - 3) Include spare terminals, equal to not less than **[10][20]<Insert number>** percent of used terminals.
 - 4) Include spade lugs for stranded wire.
 - 5) Install a maximum of two wires on each side of a terminal.
 - 6) Label each end of cable, wire, and tubing within panel following an approved identification system.
 - s. Polyethylene tubing may be used within panel enclosure in place of copper.
 - t. Supply each control panel with a complete set of as-built schematics, tubing, and wiring diagrams that are bound in a three-ring protective binder and located within panel.
 - u. Mount instruments and other products within control panel on an internal panel(s) and provide with nameplates. Provide engraved, laminated phenolic nameplates (black letters on a white background). Nameplates shall have at least **1/4-inch- (6-mm-)** high lettering.
 - v. Route tubing, cable and wiring located inside control panel within a raceway that has a continuous removable cover.
6. Pitot Tube Airflow Stations:
- a. Fan Inlet Airflow Sensor (Piezometer Ring):
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a) **[ebm-papst Inc.]**
 - b) **[Greenheck Fan Corporation]**
 - c) **[Twin City Fan & Blower]**
 - d) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[ebm-papst Inc.]**
 - b) **[Greenheck Fan Corporation]**
 - c) **[Twin City Fan & Blower]**
 - d) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain sensors from single source from single manufacturer.
 - 4) Provide fans with airflow measurement integral to fan inlet cones for continuously measurement of air volume flow rate.
 - 5) Fan inlet airflow sensor shall contain multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.
 - 6) Sensor points shall neither protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.
 - 7) Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.
 - 8) Sensor shall be non-intrusive and not impact fan performance.
 - 9) Product shall be a standard offering of fan manufacturer and include published

literature with supporting test data to validate sensor performance.

7. Thermal Airflow Measurement Stations:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **[Ebtron, Inc]**
 - 3) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **[Ebtron, Inc]**
 - 3) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain stations from single source from single manufacturer.
- d. Description: Airflow station shall consist of one or more sensor probes and a remotely mounted microprocessor-based transmitter.
- e. Performance:
 - 1) Capable of independently processing up to **[16]<Insert number>** independently wired sensor assemblies.
 - 2) Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
 - 3) Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output unless temperature sensor has an accuracy of **0.1 deg F (0.06 deg C)**.
 - 4) Listed and labeled by an NRTL as successfully tested as an assembly in accordance with UL 873 or UL 60730.
 - 5) Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-plenum-rated cable placed in conduit.
 - 6) Each flow station shall be factory calibrated at a minimum of **[six][16]<Insert number>** airflow rates and **[two][three]<Insert number>** temperatures to standards that are traceable to NIST.
 - 7) Individual Sensor Airflow Accuracy: Within **[2][3]<Insert number>** percent of reading over the entire operating airflow range.
 - 8) Thermal Airflow Station Assembly Airflow Accuracy: Within **[2][3][5]<Insert number>** percent of reading over the entire operating airflow range.
 - a) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets performance requirements throughout the measurement range.
 - 9) Temperature Accuracy: Within **0.2 deg F (0.11 deg C)** over entire operating range of **minus 20 to plus 140 deg F (minus 29 to plus 60 deg C)**.
 - 10) Sensor Ambient Operating Temperature Range: **Minus 20 to plus 160 deg F (Minus 29 to plus 71 deg C)**.
 - 11) Transmitter Ambient Operating Temperature Range: **Minus 20 to plus 120 deg F (Minus 29 to plus 49 deg C)**.

- 12) Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, noncondensing.
- 13) Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
- 14) Pressure Drop: **0.05 inch wg (12.5 Pa) at 2000 fpm (10.2 m/s)** across a **24-by-24-inch (600-by-600-mm)** area.
- 15) Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than **[1][2]<Insert number>** percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan to deliver Project design airflow indicated.

f. Sensor Assemblies:

- 1) Each sensor probe shall contain two individually wired, hermetically sealed **[bead-in-glass]**thermistors.
- 2) Mount thermistors in sensor using a marine-grade, waterproof material.
- 3) Thermistor leads shall be protected and not exposed to environment.
- 4) Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.
- 5) Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
- 6) Sensor Probe Material: Gold anodized, extruded Alloy 6063 aluminum tube or Type 304 stainless steel.
- 7) Probe Assembly Mounting Brackets Material: Type 304 stainless steel.

g. Transmitter:

- 1) Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
- 2) Capable of field configuration and diagnostics using an onboard push-button interface and digital display.
 - a) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:
 - b) Integral protection from transients and power surges.
 - c) Circuitry to ensure reset after power disruption, transients, and brownouts.
 - d) Integral transformer to convert field power source to operating voltage required by instrument.

h. Remote Signal Interface:

- 1) Linear Analog Signals for Airflow and Temperature: Fuse protected and isolated, **[field selectable],[0 to 10 V dc][or][4 to 20 mA]**.
- 2) RS-485: BACnet-ARCNET, BACnet-MS/TP, and Modbus-RTU.
- 3) 10 Base-T Ethernet: BACnet Ethernet, BACnet-IP, Modbus-TCP, and TCP/IP.
- 4) LonWorks free topology.

8. Flow Transmitters for Pitot Tube Sensors:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- 1) **[Air Monitor; an ONICON Brand]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sensors from single source from single manufacturer.
 - d. Receives total and static pressure signals from a flow element, amplify, extract the square root, and scale the signal to produce a 4- to 20-mA dc output signal linear to airflow.
 - e. Housed in NEMA 250, Type 1 enclosure.
 - f. Assembly constructed so that shock, vibration, and pressures surges of up to **1 psig (6.9 kPa)** will neither harm transmitter nor affect its accuracy.
 - g. Provide transmitter with an automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. Automatic zeroing circuit shall re-zero transmitter to within 0.1 percent of true zero.
 - h. Performance:
 - 1) Range: At least 20 percent below minimum airflow and 20 percent greater than design airflow.
 - 2) Calibrated Span: Field adjustable, minus 40 percent of the range.
 - 3) Accuracy: Within 0.10 percent of natural span.
 - 4) Repeatability: Within 0.15 percent of calibrated span.
 - 5) Linearity: Within 0.2 percent of calibrated span.
 - 6) Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
 - i. Equip transmitter with an integral digital LED or LCD for continuous indication of airflow.
 - j. Install in control panel.
9. Humidity Sensors and Transmitters with Digital Display:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Vaisala]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Vaisala]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sensors and transmitters from single source from single manufacturer.
 - d. Performance:
 - 1) Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 2.5 percent from 90 to 100 percent

- relative humidity when operating between **60 to 77 deg F (16 to 25 deg C)**.
 - 2) Relative Humidity Range: Zero to 100 percent.
 - 3) Factory calibrated and NIST traceable with certificate included.
 - e. Construction:
 - 1) Provide housing with remote sensor probe for ducted applications.
 - a) Duct Sensor Body: 300 series stainless steel or chrome-plated aluminum, at least **2 inches (50 mm)** long for duct-mounted applications.
 - b) Provide sensor with cable for field installation in conduit.
 - c) For duct-mounted applications, thread the sensor assembly for connection to a threaded mounting flange.
 - 2) Provide general-purpose humidity sensor unless application requires special requirements. Provide sensor with sintered stainless steel filter.
 - 3) Housing shall be ABS/PC plastic or powder-coated aluminum.
 - 4) Housing Classification: NEMA 250, Type 4 or Type 4X.
 - 5) Provide housing with wall-mounting plate.
 - f. Output Signal: Two-wire, 4- to 20-mA output signal with a drive capacity of at least 500 ohms at 24 V dc.
 - g. Provide unit with a digital display of relative humidity in percent.
10. Air Pressure Sensors:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Dwyer Instruments, Inc]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Dwyer Instruments, Inc]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sensors from single source from single manufacturer.
 - d. Insertion length shall be at **[4 inches (100 mm)][6 inches (150 mm)][8 inches (200 mm)][12 inches (300 mm)]**.
 - e. Sensor with four radial holes of **0.04-inch (1-mm)** diameter.
 - f. **[Brass][or][stainless steel]** construction.
 - g. Sensor with threaded end support, sealing washers, and nuts.
 - h. Connection: **NPS 1/4 (DN 6)** compression fitting.
11. Air-Pressure Differential Indicating Transmitter, Switch, and Controller:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**



- 1) [Dwyer Instruments, Inc]
 - 2) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [Dwyer Instruments, Inc]
 - 2) <Insert manufacturer's name>
- c. Source Limitations: Obtain from single source from single manufacturer.
- d. Description:
- 1) Three-in-one instrument, including digital display, control relay switches, and a transmitter with a current output.
 - 2) Field configurable for pressure, velocity, and volumetric flow applications through user interface.
 - 3) Select instrument range based on application. Range shall be approximately 2 times set point.
- e. Performance:
- 1) Accuracy Including Hysteresis and Repeatability:
 - a) Within 1 percent for ranges less than **5 inches wg (1250 Pa)**.
 - b) Within 0.5 percent at **77 deg F (25 deg C)** for other ranges.
 - 2) Stability: Within 1 percent per year.
 - 3) Response Time: 250 ms.
 - 4) Overpressure: **5 psig (34 kPa)** for instrument ranges less than **50 inch wg (12.5 kPa)** and **9 psig (62 kPa)** for **100-inch wg (25-kPa)** range.
 - 5) Temperature Limits: **32 to 140 deg F (0 to 60 deg C)**.
 - 6) Thermal Effects: 0.020 percent per deg F.
 - 7) Warm-up Period: One hour.
- f. Controller Programming through Menu Keys to Access Five Menus:
- 1) Security level.
 - 2) Pressure, velocity, or flow application.
 - 3) Engineering units.
 - 4) K-factor for use with flow application.
 - 5) Set-point control only; set-point and alarm operation; and alarm operation as high, low, or high/low with manual or automatic reset and delay.
 - 6) View high and low readings.
 - 7) Digital dampening for smoothing erratic applications.
 - 8) Scaling of analog output to fit range and field calibration.
- g. Display:
- 1) Digital, four-digit display with backlight, with **0.4-inch- (10-mm-)** high, alphanumeric characters.
 - 2) Four indicators; two for set point and two for alarm status.
- h. Operator Interface:

- 1) Set-point adjustment through keypad on face of instrument.
 - 2) Zero and span adjustments accessible through menu.
 - 3) Programming through keypad.
 - i. Analog Output Signal:
 - 1) Two-wire, 4- to 20-mA dc current source.
 - 2) Signal capable of operating into a 900-ohm load.
 - j. Digital Output Signal:
 - 1) Two SPDT relays.
 - 2) Each rated for 1 A at 30 V ac or dc.
 - k. Construction:
 - 1) Die cast-aluminum casing and bezel.
 - 2) Threaded, **NPS 1/8 (DN 6)** connections on side and back.
 - 3) Vertical plane mounting.
 - 4) NEMA 250, Type 1.
 - 5) Nominal **4-inch- (100-mm-)** diameter face.
 - 6) Mounting Bracket: Appropriate for installation.
12. Carbon Dioxide Sensors/Transmitters:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Vaisala]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Vaisala]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sensors/transmitters from single source from single manufacturer.
 - d. Description:
 - 1) NDIR technology or equivalent technology providing long-term stability and reliability.
 - 2) Two-wire, 4- to 20-mA output signal; linearized to carbon dioxide concentration in ppm.
 - e. Construction:
 - 1) House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 4.
 - 2) Equip with digital display for continuous indication of carbon dioxide concentration.
 - f. Performance:

- 1) Measurement Range: 0 to 2000 ppm.
 - 2) Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
 - 3) Repeatability: Within 1 percent of full scale.
 - 4) Temperature Dependence: Within 0.05 percent of full scale over an operating range of **25 to 110 deg F (minus 4 to plus 43 deg C)**.
 - 5) Long-Term Stability: Within 5 percent of full scale after more than five years.
 - 6) Response Time: Within 60 seconds.
 - 7) Warm-up Time: Within five minutes.
- g. Provide calibration kit. Turn over to Owner at start of warranty period.
13. Air Temperature Sensors:
- a. Platinum Resistance Temperature Detector (RTD): Common Requirements:
- 1) 100 or 1000 ohms at 0 deg C and a temperature coefficient of 0.00385 ohms/ohm/deg C.
 - 2) Two-wire Teflon insulated **22-gauge (0.65-mm)** stranded copper leads.
 - 3) Performance Characteristics:
 - a) Range: **Minus 50 to plus 275 deg F (Minus 46 to plus 135 deg C)**.
 - b) Interchangeable Accuracy: At **32 deg F (0 deg C)** within **0.5 deg F (0.3 deg C)**.
 - c) Repeatability: Within **0.5 deg F (0.3 deg C)**.
 - d) Self-Heating: Negligible.
 - 4) Transmitter Requirements:
 - a) Transmitter required for each 100-ohm RTD.
 - b) Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.
- b. Platinum RTD, Averaging Sensor:
- 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a) **[Minco]**
 - b) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Minco]**
 - b) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain sensors from single source from single manufacturer.
 - 4) **[100][or][1000]** ohms.
 - 5) Temperature Range: **Minus 50 to plus 275 deg F (Minus 45 to plus 135 deg C)**.
 - 6) Multiple sensors to provide average temperature across entire length of sensor.
 - 7) Rigid probe of aluminum, brass, copper or stainless steel sheath.
 - 8) Flexible probe of aluminum, brass, copper or stainless steel sheath and formable to

- a **4-inch (100-mm)** radius.
 - 9) Length: As required by application to cover entire cross section of air tunnel.
 - 10) Enclosure: Junction box with removable cover; NEMA 250, Type 4.
 - 11) Gasket for attachment to duct or equipment to seal penetration airtight.
 - 12) Conduit Connection: **1/2-inch (13-mm)** trade size.
14. Air Temperature Switches:
- a. Thermostat and Switch for Low Temperature Control:
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a) **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - b) **[Siemens Industry, Inc., Building Technologies Division]**
 - c) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - b) **[Siemens Industry, Inc., Building Technologies Division]**
 - c) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain switches from single source from single manufacturer.
 - 4) General:
 - a) Two-position control.
 - b) Field-adjustable set point.
 - c) Manual reset.
 - d) NRTL listed.
 - 5) Performance:
 - a) Operating Temperature Range: **15 to 55 deg F (Minus 9 to plus 13 deg C).**
 - b) Temperature Differential: **5 deg F (2.8 deg C)**, non-adjustable and additive.
 - c) Enclosure Ambient Temperature: **Minus 20 to plus 140 deg F (Minus 11 to plus 60 deg C).**
 - d) Sensing Element Maximum Temperature: **250 deg F (121 deg C).**
 - e) Voltage: 120 V ac.
 - f) Current: 16 full-load A.
 - g) Switch Type: Two SPDT snap switches operate on coldest **12-inch (300-mm)** section along element length.
 - 6) Construction:
 - a) Vapor-Filled Sensing Element: Nominal **20 feet (6 m)** long.
 - b) Dual Temperature Scale: Fahrenheit and Celsius visible on face.
 - c) Set-Point Adjustment: Screw.
 - d) Enclosure: Painted metal, NEMA 250, Type 1.
 - e) Electrical Connections: Screw terminals.
 - f) Conduit Connection: **1/2-inch (13-mm)** trade size.

15. Air Temperature RTD Transmitters:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain transmitters from single source from single manufacturer.
- d. House electronics in NEMA 250, Type 1 enclosure. Mount transmitter in control panel.
- e. Conduit Connection: **1/2-inch (36-mm)** trade size.
- f. Functional Characteristics:
 - 1) Input:
 - a) 100-ohm platinum RTD temperature coefficient of 0.00385 ohms/ohms/deg C; two-wire sensors.
 - b) 1000-ohm platinum RTD temperature coefficient of 0.00385 ohms/ohms/deg C; two-wire sensors.
 - 2) Span (Adjustable):
 - a) Exhaust Air: **50 to 100 deg F (10 to 38 deg C)**.
 - b) Mixed Air: **Minus 40 to plus 140 deg F (Minus 40 to plus 60 deg C)**.
 - c) Outdoor: **Minus 40 to plus 140 deg F (Minus 40 to plus 60 deg C)**.
 - d) Supply Air, Cooling, and Heating: **40 to 120 deg F (4 to 49 deg C)**.
 - e) Return Air: **50 to 100 deg F (10 to 38 deg C)**.
 - 3) Output: 4- to 20-mA dc linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24 V dc.
 - 4) Zero and span field adjustments plus or minus 5 percent of span. Minimum span **50 deg F (28 deg C)**.
 - 5) Match sensor with temperature transmitter and factory calibrate together.
- g. Performance Characteristics:
 - 1) Calibration Accuracy: Within 0.1 percent of span.
 - 2) Stability: Within 0.2 percent of span for at least six months.
 - 3) Combined Accuracy: Within 0.5 percent.
- h. Provide each transmitter with a digital display.

16. Liquid Flow Meters:

- a. General: Extended range of **[10][20]<Insert number>** percent above Project design flow and **[10][20]<Insert number>** percent below Project minimum flow to signal abnormal flow

conditions.

b. In-line Body Electromagnetic Liquid Flow Meters:

- 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a) **[Armstrong International, Inc]**
 - b) **[Badger Meter, Inc.]**
 - c) **[ONICON Incorporated]**
 - d) **[Spirax Sarco Limited]**
 - e) **<Insert manufacturer's name>**
- 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Armstrong International, Inc]**
 - b) **[Badger Meter, Inc.]**
 - c) **[ONICON Incorporated]**
 - d) **[Spirax Sarco Limited]**
 - e) **<Insert manufacturer's name>**
- 3) Source Limitations: Obtain flow meters from single source from single manufacturer.
- 4) Description:
 - a) No moving parts.
 - b) Suitable for flow measurement of fluids with electrical conductivity more than 5 micro-Seimens per cm.
 - c) Inherent bi-directional flow measurement.
 - d) Flow measurement with three pipe diameters upstream and two pipe diameters downstream.
 - e) Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.
 - f) Transmitter **[integral to][remote from]** meter.
- 5) Performance:
 - a) Accuracy for Velocities between 3.3 and 33 fps (1 and 10 m/s): Within 0.2 percent of reading.
 - b) Accuracy for Velocities between 1.0 and 3.3 fps (0.3 and 1 m/s): Within 0.75 percent of reading.
 - c) Accuracy for Velocities Less than 1.0 fps (0.3 m/s): Within **0.0075 fps (0.0023 m/s)**.
 - d) Ambient Temperature: **Minus 4 to plus 140 deg F (Minus 20 to plus 60 deg C)**.
 - e) Process Temperature: **Minus 4 to plus 212 deg F (Minus 20 to plus 100 deg C)**.
 - f) Pressure: **[225 psig (1551 kPa)][580 psig (3999 kPa)]**.
- 6) Analog Output Current Signal:
 - a) Two-wire, 4- to 20-mA dc current source.
 - b) Signal capable of operating into 1000-ohm load.
 - c) Isolated.

-
- 7) Digital Output Signal: Two, programmable, digital/pulse outputs configurable for frequency, pulse, or directional flow.
 - 8) Operator Interface:
 - a) Keypad.
 - b) Digital Display: Multiple-line digital display of alphanumerical characters.
 - c) LED for normal and alarm operation.
 - 9) Construction:
 - a) Body: **[Epoxy-coated carbon steel][Type 316 stainless steel]**.
 - b) Body Liner Material: **[PTFE][Ebonite][Polypropylene]**.
 - c) Flow Tube: Type 304 stainless steel.
 - d) Connection: **[150 Class flange][300 Class flange][Threaded][Wafer]**.
 - e) Electrodes: Type 316 stainless steel. Quantity determined by manufacturer based on application.
 - 10) Electronics Enclosure:
 - a) Painted aluminum.
 - b) Removable cover.
 - c) NEMA 250, Type 4 or Type 6.
 - c. Vortex-Shedding Liquid Flow Meters with Integral Pressure and Temperature Measurement:
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a) **[Armstrong International, Inc]**
 - b) **[Badger Meter, Inc.]**
 - c) **[ONICON Incorporated]**
 - d) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Armstrong International, Inc]**
 - b) **[Badger Meter, Inc.]**
 - c) **[ONICON Incorporated]**
 - d) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain flow meters from single source from single manufacturer.
 - 4) Description:
 - a) Mass flow measurement corrected for density using vortex shedding body with integral piezoelectric pressure sensors and 1000-ohm platinum RTD.
 - b) Meter **NPS 1/2 through NPS 12 (DN 15 through DN 300)**.
 - c) Each meter shall be factory calibrated at five points from **0 to 250 fps (0 to 76 m/s)** and tagged accordingly against manufacturer's flow standards. Manufacturer shall provide a certificate of calibration for meter.
 - d) Each meter shall be programmed using Project-specific application data.

- e) Meter shall include integral diagnostics to verify installation conditions and proper operation.
- 5) Performance:
 - a) Volumetric Flow Accuracy for Liquid: Within 0.75 percent of reading for Reynolds numbers 20000 and larger.
 - b) Volumetric Flow Accuracy for Steam and Gas: Within 1 percent of reading for Reynolds numbers 20000 and larger.
 - c) Mass Flow Accuracy for Steam and Gas: Within 1.5 percent of reading for Reynolds numbers 20000 and larger.
 - d) Repeatability: Within 0.1 percent.
 - e) Long-Term Stability: Within 0.1 percent per year.
 - f) Ambient Temperature: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).**
 - g) Process Temperature: **Minus 40 to plus 464 deg F (Minus 40 to plus 240 deg C).**
 - h) Pressure: Equal to flange rating.
- 6) Output Signals:
 - a) Analog Current Signal of Flow Rate:
 - b) Two-wire, 4- to 20-mA dc current source.
 - c) Signal capable of operating into 1000-ohm load.
 - d) Analog Current Signals for Pressure and Temperature: Separate 4- to 20-mA signals for gauge pressure and temperature.
 - e) Digital Signal:
 - f) Pulse output for flow totalization. Two wire, scaled pulse, 0.5 Hz, 100 mA at 30 V dc.
 - g) HART, FSK protocol.
- 7) Operator Interface:
 - a) Keypad.
 - b) Digital Display: Two-line digital display of alphanumerical characters. Meter shall display flow rate, flow totalization, pressure, temperature, and support field programming of all parameters.
- 8) Construction:
 - a) Material: Type 316L stainless steel.
 - b) Connection: **[Class 150][Class 300][Class 600]** flange.
 - c) Enclosure:
 - d) Epoxy-painted cast aluminum.
 - e) Removable screw-on cover.
 - f) NEMA 250, Type 4 or Type 6.
 - g) Electrical Connection: Screw terminals.
 - h) Conduit Connection: Two, **1/2-inch (13-mm)** trade size.
- 9) Upstream Flow Straightener:
 - a) Meter manufacturer shall provide flow straightener where required by installation to comply with manufacturer's written installation instructions.
 - b) Straightener shall be wafer type, constructed of Type 304 stainless steel, designed to be installed between field-installed flanges.
 - c) Straightener size shall match meter size.

17. Liquid Pressure Differential Switches:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Ashcroft Inc]**
 - 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Ashcroft Inc]**
 - 2) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain switches from single source from single manufacturer.
- d. Description:
 - 1) Type 316 stainless steel double opposing bellows operate to actuate an SPDT snap switch.
 - 2) Wetted Materials: Type 316 stainless steel.
 - 3) Seal: **[Buna-N][or][FKM]**.
 - 4) Electrical Connections: Screw terminal.
 - 5) Enclosure Conduit Connection: Knock-out or threaded connection.
 - 6) User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
 - 7) High and Low Process Connections: Threaded, **NPS 1/4 (DN 10)**.
 - 8) Enclosure: NEMA 250, Type 4 or Type 4X.
 - 9) Operating Data:
 - a) Electrical Rating: 10 A at 120- to 240 V ac.
 - b) Pressure Limits: **0 to 500 psig (0 to 3447 kPa)**.
 - c) Ambient Temperature Limits: **Minus 20 to plus 150 deg F (Minus 29 to plus 66 deg C)**.
 - d) Process Temperature Limits: **20 to 300 deg F (Minus 7 to plus 149 deg C)**.
 - e) Operating Range: 2 times set point unless otherwise required by application.
 - f) Deadband: **[Adjustable][Fixed][Adjustable or fixed as required by application]**.
 - 10) Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

18. Liquid Pressure Transmitters:

- a. Liquid Gauge Pressure Transmitter with Adjustable Span:
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a) **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b) **<Insert manufacturer's name>**

- 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b) **<Insert manufacturer's name>**
- 3) Source Limitations: Obtain transmitters from single source from single manufacturer.
- 4) Performance:
 - a) Range: **Minus 300 to 300 psig (Minus 2068 to 2068 kPa).**
 - b) Span: Field adjustable.
 - c) Minimum Span: **3 psig (21 kPa).**
 - d) Reference Accuracy: Within 0.07 percent of span or better.
 - e) Stability: Within 0.125 percent of upper range limit for five years.
 - f) Overpressure Limits: **3626 psig (25 000 kPa).**
 - g) Process Temperature Limits: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).**
 - h) Ambient Temperature Limits: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).**
 - i) Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
 - j) Shock and vibration shall not harm the transmitter.
- 5) Analog Output Current Signal:
 - a) Two-wire, 4- to 20-mA dc current source.
 - b) Signal capable of operating into 1000-ohm load.
 - c) Digital signal based on HART protocol carried with current signal.
 - d) Dampening: Field selectable from zero to 30 seconds.
- 6) Operator Interface: Zero and span adjustments located behind cover.
- 7) Display: Digital, five-digit, two-line display with **0.4-inch- (10-mm-)** high, alphanumeric characters.
- 8) Construction:
 - a) Non-wetted parts of transmitter constructed of aluminum or stainless steel.
 - b) Enclosure with removable cover on each side.
 - c) Wetted parts of transmitter constructed of Type 316 stainless steel.
 - d) Threaded, **NPS 1/2 (DN 15)** process connection on bottom of instrument.
 - e) Drain/vent valve on process connection.
 - f) Two **1/2-inch (16-mm)** trade size conduit connections on side of instrument enclosure.
 - g) Screw terminal block for wire connections.
 - h) NEMA 250, Type 4X.
 - i) Mounting Bracket: Appropriate for installation.
- 9) Three-Valve Manifold:
 - a) Include with each transmitter an integrally mounted manifold.
 - b) Construct manifold body of Type 316 stainless steel.
 - c) Manifold with threaded, **NPS 1/2 (DN 15)** female process connections.

b. Liquid, Pressure-Differential Transmitter with Adjustable Span:

- 1) Manufacturers: Subject to compliance with requirements, **[provide products by the**

following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a) [Rosemount; Emerson Electric Co., Automation Solutions]
 - b) <Insert manufacturer's name>
- 2) Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a) [Rosemount; Emerson Electric Co., Automation Solutions]
 - b) <Insert manufacturer's name>
- 3) Source Limitations: Obtain transmitters from single source from single manufacturer.
- 4) Performance:
- a) Range: **Minus 300 to 300 psig (Minus 2068 to 2068 kPa).**
 - b) Span: Field adjustable.
 - c) Minimum Span: **3 psig (21 kPa).**
 - d) Reference Accuracy: Within 0.07 percent of span or better.
 - e) Stability: Within 0.125 percent of upper range limit for five years.
 - f) Overpressure Limits: **3626 psig (25 000 kPa).**
 - g) Process Temperature Limits: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).**
 - h) Ambient Temperature Limits: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).**
 - i) Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
 - j) Shock and vibration shall not harm the transmitter.
- 5) Analog Output Current Signal:
- a) Two-wire, 4- to 20-mA dc current source.
 - b) Signal capable of operating into 1000-ohm load.
 - c) Digital signal based on HART protocol carried with current signal.
 - d) Dampening: Field selectable from zero to 30 seconds.
- 6) Operator Interface: Zero and span adjustments located behind cover.
- a) Display: Digital, five-digit, two-line display with **0.4-inch- (10-mm-)** high, alphanumeric characters.
 - b) Construction:
 - c) Non-wetted parts of transmitter constructed of aluminum or stainless steel.
 - d) Enclosure with removable cover on each side.
 - e) Wetted parts of transmitter constructed of Type 316 stainless steel.
 - f) Threaded, **NPS 1/2 (DN 15)** process connection on bottom of instrument.
 - g) Drain/vent valve on process connection.
 - h) Two **1/2-inch (13-mm)** trade size conduit connections on side of instrument enclosure.
 - i) Screw terminal block for wire connections.
 - j) NEMA 250, Type 4X.
 - k) Mounting Bracket: Appropriate for installation.
- 7) Five-Valve Manifold:

- a) Include with each transmitter an integrally mounted manifold.
- b) Construct manifold body of Type 316 stainless steel.
- c) Manifold with threaded, **NPS 1/2 (DN 15)** female process connections.

19. Liquid Temperature Sensors:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain sensors from single source from single manufacturer.
- d. Resistance temperature (RTD) sensors shall comply with IEC 60751, Class B requirements.
- e. Platinum with a value of 100 ohms at 0 deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
- f. Encase RTD in a Type 316 stainless steel sheath with a **0.25-inch (8-mm)** OD.
- g. Provide three-wire, PTFE-insulated, nickel-coated, 22-gauge, stranded copper leads.
- h. Provide spring-loaded RTDs for thermowell installations.
- i. Performance Characteristics:
 - 1) Range: **Minus 328 to plus 932 deg F (Minus 200 to plus 500 deg C).**
 - 2) Interchangeable Accuracy: Within **0.54 deg F (0.3 deg C)** at **32 deg F (0 deg C).**
 - 3) Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at **752 deg F (400 deg C).**
 - 4) Hysteresis: Within 0.04 percent of range.
 - 5) Response Time: 62.8 percent of change in four seconds with water flowing across sensor at **3 fps (0.9 m/s).**
- j. Thermowells:
 - 1) Stem: **[Straight][or][stepped][or][tapered]** shank formed from solid bar stock.
 - 2) Material: **[Type 304][or][Type 316]** stainless steel.
 - 3) Process Connection: Threaded, **NPS 3/4 (DN 20).**
 - 4) Sensor Connection: Threaded, **NPS 1/2 (DN 15).**
 - 5) Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
 - 6) Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends beyond the face of the insulation covering.
 - 7) Length: As required by application and pipe size.
 - 8) Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.
- k. Connection Heads:
 - 1) Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.
 - 2) Terminals: Six or eight as required by sensor.

- 3) Conduit Connection: **1/2-inch (13-mm)** trade size.
 - 4) Sensor Connection: **NPS 1/2 (DN 15)**.
 - I. Assembly: Sensor manufacturer shall furnish sensor, thermowell, and sensor connection head to provide a matched assembly.
20. Liquid Temperature Transmitters:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain transmitters from single source from single manufacturer.
 - d. Enclosure: House electronics in NEMA 250, **[Type 4][or][Type 4X]** enclosure.
 - e. Enclosure Connection: **1/2-inch (13-mm)** trade size.
 - f. Functional Characteristics:
 - 1) Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, three-wire sensors.
 - 2) Default Span (Adjustable):
 - a) Chilled Water: **0 to 100 deg F (Minus 18 to plus 38 deg C)**.
 - b) Heating Hot Water: **32 to 212 deg F (0 to 100 deg C)**.
 - c) **<Insert system and span>**.
 - 3) Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
 - 4) Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of **50 deg F (28 deg C)**.
 - 5) Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.
 - g. Performance Characteristics:
 - 1) Calibration Accuracy: Within 0.1 percent of the span.
 - 2) Stability: Within 0.2 percent of the span for at least six months.
 - 3) Combined Accuracy: Within 0.5 percent.
21. Control Transformers:
- a. Size each transformer for the total connected load, plus an additional 25 percent of the connected load.
 - b. Each transformer shall be at least 100 VA.

- c. Provide transformer with both primary and secondary fuses.
22. 25-V dc Power Supply:
- a. Plug-in style suitable for mating with a standard eight-pin octal socket.
 - b. Enclose circuitry within a housing.
 - c. Include line and load regulation to ensure a stable output. To protect both power supply and load, include power supply with an automatic current limiting circuit.
 - d. Performance:
 - 1) Output voltage nominally 25 V dc within 5 percent.
 - 2) Output current up to 100 mA.
 - 3) Input voltage nominally 120 V ac, 60 Hz.
 - 4) Load regulation within 0.5 percent from 0- to 100-mA load.
 - 5) Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
 - 6) Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.
23. Instrument Identification:
- a. Engraved tag bearing instrument identification.
 - 1) Each tag identifying an instrument shall have a unique identification that does not match identification of a similar device.
 - 2) Tag field instruments identified by equipment being controlled or monitored, followed by point identification used on I/O schematics.
 - 3) Example: DDC-AHU-01.01; PDIT1.
 - b. Letter size shall be minimum **1/4 inch (6 mm)** high.
 - c. Letter type shall be sans serif gothic bold style.
 - d. Lettering and background color scheme shall be white letters on black background.
 - e. Tag shall be engraved phenolic constructed of three layers of pressure rigid laminate. Top and bottom layers are color-coded, contrasting white center is exposed by engraving through outer layer. Engrave both sides. Material shall be stain proof, heat resistant, non-conductive, or non-corrosive.
 - f. Tag shall be fastened to equipment/instrument with drive pins or attached with a stainless steel chain.
 - g. Instruments furnished with identification tags provided by original manufacturer do not require an additional tag.
24. Checkout Procedures:
- a. Check instruments for proper location and accessibility.
 - b. Check instruments for proper installation for direction of flow, elevation, orientation, and other applicable considerations.
 - c. Damper Check-out: Verify that proper blade alignment, either parallel or opposed, has been provided.
25. Calibration and Adjustment:
- a. Calibrate every instrument.
 - b. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
 - c. Equipment and procedures used for calibration shall meet requirements of instrument manufacturer's written instructions. Test equipment used in calibration of instruments shall have an accuracy at least double that of instrument being calibrated.
 - d. Calibrate each instrument in accordance with the accuracy outlined in instruction manual

- supplied for instrument by manufacturer.
- e. Control System Inputs and Outputs:
- 1) Check analog inputs using a precision voltage or current source at zero, 50, and 100 percent of span.
 - 2) Check analog outputs using a milliampere meter at zero, 50, and 100 percent output.
 - 3) Check digital inputs using a jumper wire.
 - 4) Check digital outputs using an ohmmeter to test for contact making or breaking.
 - 5) Check resistance temperature inputs at zero, 50, and 100 percent of span using a precision-resistant source.
 - a) Flow: Set differential pressure flow transmitters for zero and 100 percent values with three-point calibration accomplished at 100, 50, and 90 percent of span.
 - b) Gas: Calibrate gas transmitters at zero, 50, and 100 percent of span.
 - c) Humidity: Calibrate relative humidity transmitters at zero, 50, and 100 percent of span.
 - d) Pressure: Calibrate pressure transmitters at zero, 50, and 100 percent of span.
 - e) Temperature: Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.
 - f) Dampers: Stroke and adjust control dampers following the recommended procedure from manufacturer, such that damper is 100 percent open and closed.
 - g) Replace out of tolerance instruments failing the test.
 - h) Provide diagnostic and test instruments for calibration and adjustment.

SS. Smoke Detectors:

1. System, Duct Smoke Detectors: For connection to conventional fire-alarm system. Coordinate requirements with **[Section 284600 "Fire Detection and Alarm."][Section 284614 "Single- and Multiple-Station Alarms."][Section 284600 "Fire Detection and Alarm" and Section 284614 "Single- and Multiple-Station Alarms."]**
 - a. Operating at 24-V dc, nominal.
 - b. Detectors shall be **[four][two]**-wire type.
 - c. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
 - d. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - e. Integral Visual-Indicating Light: LED type, indicating detector has operated **[and power-on status]**.
 - f. Provide multiple levels of detection sensitivity for each sensor **[, with alarm-verification feature]**.
 - g. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
 - 1) Remote indication **[and test]** station. **[Operating key switch initiates an alarm test.]**
 - 2) Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC systems.
 - 3) Sampling Tubes: Design and dimensions as recommended by manufacturer for specific size, air velocity, and installation conditions where applied.
 - 4) Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2. Nonsystem, Single-Station Duct Smoke Detectors:
 - a. Nonsystem smoke detectors shall be listed as compatible with fire-alarm equipment installed or shall have a contact closure interface listed for the connected load.
 - b. Nonsystem smoke detectors shall meet the monitoring for integrity requirements in NFPA 72.
 - c. Comply with UL 268A; operating at 120 V ac.
 - d. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to mounting brackets air-handling unit. Provide terminals in the fixed base for connection to building wiring.
 - 1) Enclosure: NEMA 250, Type 4X; listed for use with the supplied detector.
 - e. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific size, air velocity, and installation conditions where applied.
 - f. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.
3. Air-Handling Unit Factory Assembly:
 - a. Furnish and install smoke detectors inside air-handling units to comply with governing building codes.
 - b. Install smoke detectors in accordance with smoke detector manufacturer's written installation instructions.
 - 1) Sampling tubes shall extend the full width of airstream.
 - 2) Sampling tubes greater than **36 inches (900 mm)** long shall be supported on both ends.
 - c. Install smoke detectors within air-handling units in a location that is easily accessible for inspection, repair, and replacement of smoke detector, and in a location that does not hinder access to other internal components.
4. Air-Handling Unit Factory Testing: Functionally test smoke detectors to ensure proper operation in accordance with smoke detector manufacturer's written instructions.
5. Air-Handling Unit Factory Installation of Addressable Smoke Detectors Furnished by Building Fire-Alarm System Supplier:
 - a. Where addressable duct smoke detectors are indicated to be installed within air-handling unit casing, air-handling unit manufacturer shall install duct smoke detector components supplied by building fire-alarm system supplier.
 - b. Mount duct smoke detector sampling housing on exterior of air-handling unit casing. Locate on accessible side and coordinate with installers before installation.
 - c. Seal air-handling unit casing penetrations.
 - d. Install duct smoke detector components in accordance with written instructions furnished by supplier.
 - 1) Sampling tubes shall extend the full width of airstream.
 - 2) Sampling tubes greater than **36 inches (900 mm)** long shall be supported on both ends.
 - e. Photograph installation and transmit photos to fire-alarm system Installer before air-handling unit shipment to ensure proper installation. Fire-alarm system Installer shall review photos and provide written acceptance of installation to air-handling unit manufacturer before air-handling unit shipment.

- 1) Document date of photos and approval for record purposes.
 - 2) Make corrective measures required by fire-alarm system Installer as required for acceptance.
- f. Coordinate work schedule of air-handling unit manufacturer and fire-alarm system supplier to meet requirements of Project schedule.
- g. See [Section 284600 "Fire Detection and Alarm"]**[and]**[Section 284614 "Single- and Multiple-Station Alarms"]**<Insert Section>** for additional requirements.

TT. Catwalks, Handrails, And Ladders:

1. General:

- a. Provide elevated air-handling units and top levels of multilevel stacked units with catwalks, handrails, and ladders to provide service access.
- b. Factory-fabricate catwalks, handrails, and ladders to ensure proper alignment and attachment.
- c. Catwalks, handrails, and ladders may be disassembled and shipped separate from the air-handling unit for field installation.
- d. Design and fabricate catwalk to be completely self-supported from air-handling unit frame without need for any type of field-installed supports.
- e. Comply with OSHA requirements where requirements are more stringent than requirements indicated.
- f. Install catwalk, handrails, and ladders level and plumb.

2. Catwalks:

- a. Extend catwalks to service elevated portions of air-handling units that are accessible through access doors and panels.
- b. Catwalk width shall be of sufficient size to properly access and service equipment and maintain code-required clearances to electrical devices. Width shall be at least **[60 inches (1500 mm)]<Insert dimension>** clear between the exterior casing and handrail.
- c. Cantilever catwalk base frame from the air-handling unit base frame. Removable catwalks shall be bolted to the air-handling unit base frame at multiple points to ensure a rigid and firm attachment.
- d. Catwalk base frame material and finish shall match air-handling unit frame.
- e. Catwalk floor material shall match air-handling unit floor material.
- f. Catwalk walking surface elevation shall match floor surface inside air-handling unit.

3. Handrails:

- a. Provide catwalk with handrail, kneerail, toeboard, and vertical supports along entire length of catwalk. Comply with 29 CFR 1910.23.
- b. Handrail shall be a minimum of **[42 inches (1050 mm)]<Insert dimension>** high and comply with OSHA requirements. Vertical supports shall be spaced not more than **[96 inches (2400 mm)]<Insert value>** o.c.
- c. Construct handrail, kneerail, and vertical supports from not less than nominal **[1-1/2-inch-(38-mm-)]<Insert dimension>** diameter tube.
- d. Handrail shall be capable of withstanding a live load force of not less than **[100 lb/ft. (450 N/300 mm)]** and a **[200-lb (900-N)]<Insert value>** concentrated force in any direction.
- e. Provide lift-out sections of handrail to facilitate removal of air-handling unit internal components from the top-level to grade.
- f. Provide self-closing gate at ends of catwalk accessible by ladders to provide fall protection.
- g. Construct handrails, kneerails, toeboards, and vertical supports of

[aluminum][fiberglass][galvanized-steel][or][stainless steel] materials.

1) Finish: Hot-dip galvanize assemblies constructed of steel after fabrication.

4. Ladders with Safety Cages:

- a. Provide a permanently attached ladder at **[one][each]** end of catwalk.
- b. Ladder shall rise from building structural floor to the top of handrail.
- c. Provide for construction tolerance and adjustable means to fasten the ladder at its base to the building structural floor.
- d. Fabricate ladders with dimensions, spacing, details, and anchorages as required.
- e. Comply with requirements of ALI A14.3 and 29 CFR 1910.27.
- f. Support each ladder at top and bottom. Use welded or bolted brackets, designed for adequate support and anchorage, and to hold ladder **[7 inches (175 mm)]<Insert dimension>** clear from catwalk walking surface.
- g. Extend rails at least **[42 inches (1050 mm)]<Insert dimension>** above top rung, and return rails with secure handholds fastened to handrail.
- h. Construct ladders of **[aluminum][fiberglass][galvanized-steel][or][stainless steel]** materials.

1) Finish: Hot-dip galvanize ladders, brackets, and fasteners constructed of steel after fabrication.

- i. Provide non-slip surface on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung that has a non-slip top surface.

UU. Hardware:

1. Screws:

- a. For Galvanized-Steel Materials: Self-tapping, hex-head, **[zinc-plate steel][or][300 series stainless steel]** screws with a neoprene gasket encapsulated by a **[zinc-plate steel][or][300 series stainless steel]** washer.
- b. For Aluminum and Stainless Steel Materials: Self-tapping, hex-head, 300 series stainless steel screws with a neoprene gasket encapsulated by a 300 series stainless steel washer.
- c. Provide protective covers on exposed screws to prevent personnel injury.

2. Bolts, Nuts, and Washers:

- a. For Joining Galvanized and Painted Carbon Steel Materials: Hex-head, high-strength, **[galvanized steel][or][300 series stainless steel]**.
- b. For Joining Aluminum and Stainless Steel Materials: Hex-head, high-strength, 300 series stainless steel.
- c. Use washers and lock washers at each bolted connection.
- d. Select bolt size and spacing sufficient for load and application.

VV. Welding:

1. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
 - a. Use welding materials with corrosion properties equal to material being welded.
2. Use welders that are certified to weld at least **[twice]** the thickness of the material to be welded. Certification shall be within **[three][six]<Insert number>** months of work being performed.

3. Welds shall be continuous, full-penetration welds unless otherwise indicated. Intermittent welds, stitch welds and tack welds are permitted only in specific applications indicated.
4. Use welders and welding procedures complying with the following:
 - a. Piping Systems: Section IX of the ASME Boiler and Pressure Vessel Code and Section V of ASME B31.1.
 - b. Structural Aluminum: AWS D1.2/D1.2M.
 - c. Structural Carbon Steel: AWS D1.1/D1.1M.
 - d. Structural Stainless Steel: AWS D1.6/D1.6M.
 - e. Sheetmetal: AWS D9.1/D9.1M.

WW. Painting:

1. General:
 - a. Painted OEM components do not require additional coating other than touch-up to damaged areas. Match the touchup coating to surrounding undamaged surfaces.
 - b. Finish miscellaneous surfaces to match continuous surfaces.
 - c. Protect mill galvanized surfaces that are exposed to view, such as raw steel cuts and damage by welding, with multiple coats of matching galvanized paint.
 - d. Protect mill galvanized surfaces that are concealed, such as raw steel cuts and damage by welding, with multiple coats of zinc-rich paint or matching galvanized paint.
 - e. Touch up or entirely repaint surface finishes, damaged during shipment and installation, to the original condition, using original materials and methods.
2. Preparation:
 - a. Submit proposed manufacturer's written preparation and application instructions for information.
 - b. If paint manufacturer's recommended preparation requirements differ from those indicated, use the more stringent requirements.
 - c. Structural carbon steel to be painted shall be deburred, ground smooth, cleaned, and blasted in accordance with **[SSPC-SP 6/NACE No. 3]****[or]****[SSPC-SP 10/NACE No. 5]**.
 - d. Before applying a primer and a finish coat, remove oil and grease from surfaces to be coated using clean rags soaked in thinner in accordance with SSPC-SP 1.
 - e. Treat surfaces to be painted to ensure that paint adheres.
3. Primer:
 - a. Rust-inhibiting type, with a minimum dry film thickness of **[1][2]<Insert value>** mil(s) per coat.
 - b. Apply at least **[two]<Insert number>** coats of primer to unfinished carbon steel surfaces and at least one coat of primer to other surfaces.
 - c. Use primer that is compatible with substrate and finish coat.
4. Finish Coat:
 - a. Finish coat painting system shall be **[alkyd-enamel][epoxy][polyurethane]<Insert coating>**.
 - b. Use dry film thickness recommended by paint manufacturer for each coat. Total dry film thickness of all finish coats not less than **[3][5]<Insert value>** mils.
 - c. Painted Surfaces Minimum Properties:
 - 1) Salt Spray ASTM B117: 5 percent salt solution fog at **95 deg F (35 deg C)** for **[1000][2000][4000]<Insert value>** hours with no deterioration.

- 2) Adhesion, ASTM D3359: When the coating is cut into **0.0625-inch (1.6-mm)** squares and 3M No. 600 tape is suddenly removed, there is no loss of adhesion.
 - 3) Acid Resistance ASTM D3260: 15-minute exposure to 10 percent hydrochloric acid at room temperature with no effect.
 - 4) Alkali Resistance ASTM D1647: 15-minute exposure to 10 percent sodium hydroxide at room temperature with no effect.
 - 5) Humidity Resistance ASTM D2247: 850-hour exposure to **100 deg F (38 deg C)** and at least 95 percent relative humidity with no effect.
 - 6) Pencil Hardness ASTM D3363: A hardness of 1H.
- d. Finish coat color shall be selected by Architect and not be limited to manufacturer's standard offering.
- 1) Submit a written request for color selection and indicate in the request the date color selection must be returned without impacting schedule.
5. Application: Paint the following surfaces with primer and finish coat indicated:
- a. Unfinished carbon steel surfaces.
 - b. Exposed mill galvanized-steel surfaces of air-handling unit casing exterior.
 - c. Exposed aluminum surfaces of air-handling unit casing exterior.
 - d. Exposed stainless steel surfaces of air-handling unit casing exterior.

XX. Cleanliness Requirements:

1. General:
 - a. Provide equipment that has been manufactured, shipped, stored, and installed maintaining highest degree of cleanliness possible.
 - b. Owner Cleanliness Inspection: Air-handling unit(s) cleanliness is subject to Owner cleanliness inspection [**and must pass a white glove test**]before packaging for shipment.
 - c. **<Insert requirements>**.
2. During Manufacturing:
 - a. Clean materials to be free of mill grease, oxidation, dirt, dust, and other impurities before manufacturing and assembly.
 - b. Protect casing materials from contamination during manufacturing and assembly.
 - c. Use sealing materials that do not outgas.
 - d. Provide OEM components and equipment from their respective manufacturers free of grease, oxidation, and dirt. Store OEM components and equipment indoors. Cover and protect OEM components and equipment to maintain cleanliness. Follow OEM instructions for equipment storage.
3. After Manufacturing:
 - a. Before shipment, after unit is completely assembled, clean unit inside and out.
 - 1) Vacuum entire inside to remove dirt, dust, and debris using HEPA-filtered vacuum equipment.
 - 2) Purge hard to reach surfaces with dry, oil-free, compressed or bottled nitrogen.
 - 3) Wipe down all surfaces, inside and out, with a residue-free cleaning agent.
 - b. Protect unit to maintain cleanliness.
4. Shipping:

- a. Protect interior and exterior of air-handling unit from exposure to weather dirt, dust, and debris during shipment and rigging.
- b. Cover openings with puncture-resistant durable coverings to ensure that cleanliness is maintained inside unit while providing an air- and watertight seal.

5. On-Site Storage:

- a. If air-handling unit is to be stored before installation, Installer shall work closely with air-handling unit manufacturer for air-handling unit manufacturer to provide adequate protection at the factory to ensure that cleanliness for both unit interior and unit exterior is maintained. This protection shall remain in place until unit startup is performed.
- b. For extended periods of storage, provide a means to rotate fan and motor assemblies on a periodic basis (as recommended in writing by manufacturer) without compromising unit cleanliness.

YY. Accessories:

1. Tool Kit:

- a. Manufacturer shall assemble a tool kit specially designed for use in servicing air-handling units furnished.
- b. Include only special tools required to service air-handling unit components not readily available for purchase by Owner service personnel in performing routine maintenance.
- c. Place tools in a lockable case with hinged cover.
- d. Mark case cover with large and permanent text to indicate special purpose of tool kit, such as "Air-Handling Unit Tool Kit." Text size shall be at least [1 inch (25 mm)]<Insert dimension> high.
- e. Provide a list of each tool furnished and permanently attach the list to underside of case cover. Text size shall be at least [1 inch (25 mm)]<Insert dimension>high.

2.5 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. AHRI 260 (I-P): Air-handling unit sound ratings shall be in accordance with AHRI 260 (I-P), "Sound Rating of Ducted Air Moving and Conditioning Equipment."
2. AHRI 261 (SI): Air-handling unit sound ratings shall be in accordance with AHRI 261 (SI), "Sound Rating of Ducted Air Moving and Conditioning Equipment."
3. AHRI 410: Air-handling unit coils shall be rated in accordance with AHRI 410 and shall be listed by AHRI[and labeled in accordance with AHRI].
4. AHRI 1060 (I-P) Certification: Air-handling units that include [energy wheels][fixed plate heat exchangers][and][heat pipe heat exchangers] shall be rated in accordance with AHRI 1060 (I-P) and shall be listed by AHRI[and labeled in accordance with AHRI].
5. AHRI 1061 (SI) Certification: Air-handling units that include [energy wheels][fixed plate heat exchangers][and][heat pipe heat exchangers] shall be rated in accordance with AHRI 1061 (SI) and shall be listed by AHRI[and labeled in accordance with AHRI].

B. AMCA Compliance:

1. AMCA 201: Air-handling unit manufacturer shall evaluate fan's performance within the air-handling unit in accordance with AMCA 201, "Fans and Systems" and account for conditions within the air-handling unit that could be detrimental to fan's performance by adjusting the fan performance indicated on Drawings.
2. AMCA 205 Certification: Air-handling unit fan's fan efficiency grade (FEG) shall be rated in

accordance with AMCA 205, "Energy Efficiency Classifications for Fans"[**and shall bear the AMCA-certified fan efficiency grade seal**].

3. AMCA 210 Certification: Air-handling unit fan's air performance shall be rated in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating"[**and shall bear the AMCA-certified air ratings seal**].
4. AMCA 300: Air-handling unit fan's sound performance shall be rated in accordance with AMCA 300, "Reverberant Room Method for Sound Testing of Fans."
5. AMCA 301 Certification: Air-handling unit fans sound performance shall be rated in accordance with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data"[**and shall bear the AMCA-certified sound ratings seal**].
6. AMCA 500-D: Air-handling unit damper's performance shall be rated in accordance with AMCA 500-D, "Laboratory Methods of Testing Dampers for Rating"[**and shall bear the AMCA-certified air ratings seal**].

C. NFPA Compliance:

1. NFPA 70: Electrical components, devices, and accessories shall be listed and labeled by a qualified testing agency, and marked for intended location and application.
2. NFPA 90A: Design, fabrication, and installation of air-handling units and components shall comply with NFPA 90A.

D. UL Compliance:

1. UL 1598 Certification: Air-handling unit UVGI shall be NRTL listed and labeled in accordance with UL 1598, "Luminaires."
2. UL 1995 Certification: Where indicated, air-handling unit components shall be NRTL listed and labeled in accordance with UL 1995, "Standard for Safety Heating and Cooling Equipment."

2.6 SOURCE QUALITY CONTROL - INDEPENDENT LABORATORY TESTING

A. General:

1. Project-specific testing by an independent laboratory is not required if air-handling unit manufacturer has written independent laboratory test results of past tests performed on same casing construction proposed for use on this Project.
2. If Project-specific testing is required, testing shall be performed in ample time to include test reports with submittals and before manufacturing of air-handling units. Include sufficient lead time for unit delivery, installation, and testing required by construction schedule.

B. Casing Structural Deflection Test:

1. Include service of an independent testing laboratory to verify casing structural deflection requirements indicated.
 - a. In lieu of independent laboratory testing, manufacturer may perform factory deflection testing of proposed construction to prove compliance if witnessed by **[Architect][and][Owner]**. Manufacturer shall bear cost of labor and travel expenses to witness testing.
2. Test casing construction to performance criteria indicated.
3. Test casing construction proposed for use on Project. Include, at a minimum, particulars such as metal materials and thickness, internal support and reinforcing, and insulation material and thickness.
4. Test largest full-size casing panel proposed for use on Project.
5. Test proposed construction of walls, floor, and roof. Include a separate test for each unique

- casing construction proposed.
- 6. Submit test reports for each test to show compliance with performance indicated.

C. Casing Airborne Sound Transmission Test:

- 1. Include services of an independent testing laboratory to test proposed casing construction for sound transmission. Include a separate test for each unique casing construction proposed.
- 2. Conduct tests in accordance with ASTM E90.
- 3. Determine sound transmission class by using ASTM E413.
- 4. Test proposed construction of walls and roof.
- 5. Test proposed construction of floor assembly only if air-handling unit is not installed on a concrete housekeeping pad or building structural floor.
- 6. Submit test reports for each test to show compliance with performance indicated.

D. Casing Sound Absorption Test:

- 1. Include services of an independent testing laboratory to verify casing sound absorption coefficients for perforated casing panels. Provide a separate test for each unique casing construction proposed.
- 2. Conduct tests in accordance with ASTM C423 and ASTM E795.
- 3. Test proposed construction of walls and roof.
- 4. Submit test reports to show compliance with performance indicated.

2.7 SOURCE QUALITY CONTROL - AIR-HANDLING UNIT FACTORY TESTS

A. Witness of Testing: Allow **[Architect][Commissioning Agent][Construction Manager][and][Owner]<Insert entity>** access to place where air-handling units are being tested for witness testing.

- 1. Submit written notification at least **[30][20]<Insert number>** days in advance of testing.
- 2. Schedule testing at mutually agreeable dates and times.

B. Witness Testing Travel Expenses:

- 1. Include in bid the cost of travel expenses to witness factory testing. Total cost for travel expenses shall be clearly indicated separately in bid.
- 2. Expenses shall include roundtrip **[coach][or][first]** class airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation and parking, and all associated taxes and fees.
- 3. Exclude other incidental expenses not indicated.
- 4. Include travel expenses for **[one][two]<Insert value>** representative(s) with origin of **<Insert city and state>**.

C. Casing Leakage Test:

- 1. Perform a leak test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and arrangement]<Insert requirement>**.
- 2. Follow testing procedures in accordance with ASHRAE 111.
- 3. Perform leak test before shipping first air-handling unit **[of unique size and arrangement]**.
- 4. Test results shall indicate that units comply with leakage requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
- 5. Prepare test reports in accordance with ASHRAE 111.
- 6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and

witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

D. Casing Structural Deflection Test:

1. Perform a structural deflection test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and arrangement][only one air-handling unit with the worst-case condition]<Insert requirement>**.
2. Pressurize and load air-handling units to the performance criteria indicated for structural deflection. Test air-handling unit **[floors][walls and roofs]**.
3. Test results shall indicate that units comply with deflection requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
4. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

E. Functional Run Test:

1. Run test each unit before shipment.
2. Test and balance fans to comply with vibration requirements indicated.
3. Energize each electrical device to ensure it is operational.
 - a. Take meter readings for volts, amperes, and kVA_r on each phase leg of each motor.
 - b. Take meter readings for volts, amperes, and kVA_r on each single-phase power connection to field power.
4. Exercise each damper to ensure proper operation.
5. Exercise each access door to ensure proper fit.
6. Exercise each valve to ensure proper operation.
7. Submit a written report for each unit tested. Written report shall include, at a minimum, full name of each person witnessing test, detailed list of each unit component tested, condition observed, and corrective action required. Each line item shall have full name of the person doing the checkout and date and time the checkout was performed.

F. Fan Vibration Test:

1. Perform a fan vibration test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Energize each fan within the air-handling unit after air-handling unit final assembly and perform a vibration analysis with fan operating at design speed **[and at all speeds throughout the range from design to minimum speed]**.
3. Three vibration measurements shall be taken for each bearing in horizontal, vertical, and axial directions. Vibration measurements shall be recorded and consist of vibration amplitude verses frequency **[with filter-in]**.
4. Fan bearing measurement points shall be marked or scribed on bearings for permanent record.
5. Test results shall indicate that units comply with vibration requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and

witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

G. Acoustical Performance Test:

1. Perform an acoustical performance test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Air-handling unit acoustic performance shall be verified by factory test in accordance with AHRI 260 (I-P) or AHRI 261 (SI).
3. Air-handling unit supply-air discharge, return-air inlet, and casing radiated sound components shall be measured with air-handling unit operating at design conditions.
4. Testing Location: Perform testing in a location complying with AHRI 220, "Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment."
 - a. Test location shall be broadband qualified in accordance with AHRI 220 Section 5.1 and discrete frequency qualified in accordance with Section 5.2.
5. Operating conditions used in acoustic testing shall be verified by test in accordance with AMCA 210[**in an AMCA-accredited facility**].
6. Test results shall indicate that units comply with acoustical requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
7. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

H. Airflow Capacity Performance Test:

1. Perform an airflow capacity performance test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Operating conditions shall be verified by test in accordance with AMCA 210[**in an AMCA-accredited facility**].
3. Test results shall indicate that units comply with design airflow requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
4. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

I. Hydronic Piping Systems Testing: Pressure test factory-assembled piping systems with compressed air or water at a pressure to comply with governing codes and ASME B31.9, but not less than design pressure indicated.

1. Test results shall indicate that piping systems are without leaks. Make changes to noncompliant piping systems and retest until units comply with requirements.
2. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

- J. Steam and Condensate Piping Systems Testing: Pressure test factory-assembled piping systems with compressed air or water at a pressure to comply with governing codes and ASME B31.1 or ASME B31.9 as applicable for service, but not less than design pressure indicated.
1. Test results shall indicate that piping systems are without leaks. Make changes to noncompliant piping systems and retest until units comply with requirements.
 2. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

2.8 SOURCE QUALITY CONTROL - OEM COMPONENT FACTORY TESTS

A. Air Blender Testing:

1. Owner-witnessed performance test to demonstrate compliance with performance requirements indicated.

B. Coil Testing:

1. Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
2. Refrigerant Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
3. Steam Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than to **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
4. Coils to display a tag with inspector's identification as proof of testing.

C. Fan Vibration Testing:

1. Perform a fan vibration test for **[each fan]<Insert requirement>**.
2. Energize each fan after final assembly and perform a vibration analysis with fan operating at design speed **[and at all speeds throughout the range from design to minimum speed]**.
3. Three vibration measurements shall be taken for each bearing in the vertical, and axial directions. Vibration measurements shall be recorded and consist of vibration amplitude verses frequency **[with filter-in]**.
4. Fan bearing measurement points shall be marked or scribed on bearings for permanent record.
5. Test results shall indicate units comply with vibration requirements indicated. Make changes to noncompliant fans and retest until fans comply with requirements.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single fan, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine air-handling units before installation. Reject units with physical damage, and air-handling unit components that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for the following before installation of air-handling units:
 - 1. Structural substrate mounting and anchorage to verify actual sizes, types, and locations.
 - 2. Piping systems to verify actual sizes, types, and locations of connections.
 - 3. Ductwork and plenums to verify actual sizes, types, and locations of connections.
 - 4. Electrical services and controls to verify actual sizes, types, and locations of connections.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF OUTDOOR, CUSTOM AIR-HANDLING UNITS

- A. Equipment Mounting: Install air-handling units at locations indicated on Drawings. Unless, otherwise indicated on Drawings, install air-handling units on concrete equipment bases.
 - 1. Units Mounted on Concrete Bases:
 - a. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - b. Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material.
 - c. Fill voids between air-handling unit bases and concrete bases using high-strength non-shrink grout.
 - d. Continuously seal between concrete bases and perimeter of air-handling unit bases with nonhardening sealant.
 - 2. Units Mounted to Structural-Steel Supports: Level unit air-handling bases using aluminum or stainless steel shims compatible with air-handling unit base material. Continuously seal between structural supports and air-handling unit bases with nonhardening sealant.
 - 3. Units Mounted Directly to Finished Floors: Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material. Continuously seal between floor and perimeter of air-handling unit bases with nonhardening sealant.
 - 4. Suspended Units: Suspend and laterally brace air-handling units from building structure by attaching to only air-handling unit bases at manufacturer-designated locations.
 - 5. Install air-handling units on curbs following air-handling unit manufacturer's written procedures.
 - a. Install gaskets before setting air-handling units on curbs.
 - b. Secure air-handling units to curbs using stainless steel fasteners.
 - c. Install curb and fasten to structure.
 - d. Coordinate curb requirements, attachment, and location before installation.
- B. Roof Openings:

1. Provide exact size and location of roof openings to trade installing structural framing and roof structure.
2. Supervise framing of openings to ensure coordinated installation with air-handling units.
- C. Seismic Control: Comply with requirements for seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- D. Equipment Clearances and Access:
 1. Arrange installation of air-handling units to provide access space around air-handling units for service and maintenance and for removal and replacement of internal components.
 2. Provide clearance and access required by governing codes and NFPA 70.
 3. At a minimum, comply with requirements indicated on Drawings and air-handling unit manufacturer's written instructions.

3.3 PROTECTION DURING CONSTRUCTION

- A. Exterior Covers: Cover air-handling units during construction with sealed covers to protect air-handling unit casing and externally mounted components from physical damage, dirt, dust and debris, paint splatter, and any other construction materials.
 1. Minor physical damage, as determined by Owner, shall be repaired by air-handling unit factory service personnel to factory-finished condition.
 2. Replace air-handling units with damage that in any way compromises the performance indicated.
- B. Internal Access: Keep access doors locked to maximum extent possible and restrict access to only authorized personnel.
 1. Open access doors only during periods authorized work inside air-handling units is required.
 2. Coordinate and monitor work inside air-handling units on a shift basis. Lock access doors once work is complete or at the end of each shift.
 3. Immediately report unauthorized access and any observed damage to Owner.

3.4 DUCT CONNECTIONS

- A. Connect ducts and plenums to air-handling unit connections. Comply with requirements in Section 233113 "Metal Ducts."
- B. Connect ducts and plenums to air-handling unit connections with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- C. Provide duct transitions required to make field connections to air-handling units.
- D. Arrange ducts and plenums to provide unobstructed access to inside of air-handling units.

3.5 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, provide unobstructed access to inside of air-handling units for service and maintenance.

- C. Connect piping to air-handling units with flexible connectors.
- D. Drain Pan Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
 - 1. Make connections to air-handling unit connections with **[flanges or]**unions.
 - 2. Extend **[dedicated]**drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
 - 3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
 - 4. Install threaded cleanouts at changes in direction.
 - 5. Secure drain piping to structure.
- E. Air-Handling Unit Floor Drains: Do not require installation of permanent drain piping.
- F. Air-Handling Unit Floor Drain Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
 - 1. Make connections to air-handling unit connections with **[flanges or]**unions.
 - 2. Extend **[dedicated]**drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
 - 3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
 - 4. Install threaded cleanouts at changes in direction.
 - 5. Secure drain piping to structure.
- G. Chilled-Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 1. Comply with requirements indicated on Drawings.
 - 2. Make connections to coils with a **[flange][or][union]**.
 - 3. Connect to each coil inlet with shutoff valve, test plug, **[pressure gauge][and][thermometer]**.
 - 4. Connect to each coil outlet with balancing valve, test plug, **[pressure gauge][thermometer][flow meter][and][shutoff valve]**.
 - 5. Connect each coil drain connection with a drain valve, which is full size of drain connection.**[Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.]**
 - 6. Connect each coil vent connection with **[automatic][or][manual]** vent, which is full size of vent connection.
- H. Hot-Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 1. Comply with requirements indicated on Drawings.
 - 2. Make connections to coils with a **[flange][or][union]**.
 - 3. Connect to each coil inlet with shutoff valve, test plug, **[pressure gauge][and][thermometer]**.
 - 4. Connect to each coil outlet with balancing valve, test plug, **[pressure gauge][thermometer][flow meter][and][shutoff valve]**.
 - 5. Connect each coil drain connection with a drain valve, which is full size of drain connection.**[Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.]**
 - 6. Connect each coil vent connection with **[automatic][or][manual]** vent, which is full size of vent connection.

- I. Steam and Condensate Coil Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap assembly, and union or flange at each coil return connection.
- J. Refrigerant Coil Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve at each supply and return connection.
- K. Steam Humidifier Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install gate valve and inlet strainer at supply connection of steam humidifiers and steam trap assemblies to condensate return connection.

3.6 ELECTRICAL CONNECTIONS

- A. Install field power to each air-handling unit electrical power connection. Coordinate with air-handling unit manufacturer and installers.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert dimension> high.

3.7 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert dimension> high.

3.8 STARTUP SERVICE

- A. Engage an air-handling unit factory[-authorized] service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, controls, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that face-and-bypass dampers provide full face flow.
7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
8. Comb coil fins for parallel orientation.
9. Verify that proper thermal-overload protection is installed for electric heaters.
10. Install new, clean filters.
11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
12. **<Insert requirement>**.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. **[Replace fan and motor pulleys as required to achieve design conditions.]**
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.
4. **<Insert requirement>**.

C. Heat Wheel Startup Service:

1. After field installation is complete, a final checkout and startup shall be completed to ensure proper purge adjustment, seal adjustment, control settings, and other key operational functions.
2. Service shall be completed by trained factory service personnel employed by heat wheel manufacturer.
3. Submit a report summarizing findings, adjustments made, and final settings.

3.9 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Before turning equipment over to Owner for use, adjust air-handling unit components that require further adjustment for proper operation. Consult air-handling unit manufacturer for instruction.
- D. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.
- E. Seasonal Adjustments: Make seasonal visits during warranty period to inspect and review operation of equipment. Make necessary adjustments for components observed to require adjustments for proper operation. Prepare and submit a report to Owner documenting each visit, observations, and any adjustments made.

3.10 CLEANING

- A. Cleaning Schedule: After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before Owner use, clean air-handling units to remove foreign material and construction dirt and dust.
- B. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.
 - 1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
 - 2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
 - 3. Clean all internal components, such as coils, dampers, filter frames, fans, and motors.
 - 4. Clean light fixtures and control devices.
- C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.
- D. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.
- E. Acceptance: Following unit cleaning submit a written request for review and [Owner] acceptance. Acceptance for cleaning of air-handling units **[with absolute filters]** must pass a white glove test.

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections: Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**.
 - 1. After field piping connections are complete, test **[hydronic][and][steam]** coils and connections for leaks.
 - 2. Charge refrigerant coils with refrigerant and test for leaks.
 - 3. Field-Assembly Supervision: Instruct Installer and supervise field installation of **[first]<Insert quantity>** air-handling unit(s) shipped in multiple pieces for field assembly.
 - 4. Roof-Mounted Field-Installation Supervision: Instruct Installer and supervise field installation of **[first]<Insert quantity>** roof-mounted air-handling unit(s).
 - 5. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Field Casing Leakage Test:
 - 1. Perform leak testing of air-handling units that include field assembly of multiple sections. Air-handling units that are shipped and installed as a single piece do not require field testing.
 - 2. Leak test **[one]<Insert value>** air-handling unit(s) of each unique size and arrangement randomly selected by **[Architect][Commissioning Agent][Owner]**.
 - 3. Follow procedures complying with ASHRAE 111.
 - 4. Assembled air-handling units shall satisfy leakage criteria indicated. Modify air-handling units that



fail to satisfy criteria and retest. For every air-handling unit that fails test, another air-handling unit shall be tested until all air-handling units tested pass leakage criteria on first attempt.

5. Submit a test report for each test indicating test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.
6. Test report shall be in accordance with ASHRAE 111.
7. Witness Testing:
 - a. Provide written notification at least [30][20]<Insert number> business days in advance of testing.
 - b. Testing shall be conducted in presence of testing and balancing agent.
 - c. Other parties such as Architect, Commissioning Agent, and Owner shall be invited to witness testing with attendance being optional.

E. Field Fan Vibration Test:

1. Perform fan vibration testing for every one out of [10]<Insert number> air-handling unit fans randomly selected by [Architect][Commissioning Agent][Owner].
2. Test after air-handling unit installation is complete.
3. Three vibration readings shall be taken for each bearing in horizontal, vertical, and axial directions. Record each reading including vibration amplitude verses frequency.
4. Modify fans that fail to satisfy performance criteria and retest. For every fan that fails test, another fan shall be tested until all fans tested pass criteria on first attempt.
5. Submit a report for each fan tested indicating air-handling unit designation, fan designation, test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.
6. Witness Testing:
 - a. Provide written notification at least [30][20]<Insert number> business days in advance of testing.
 - b. Testing shall be conducted in presence of testing and balancing agent.
 - c. Other parties such as Commissioning Agent, Architect, and Owner shall be invited to witness testing with attendance being optional.

F. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

G. Prepare test and inspection reports.

3.12 OPERATION DURING CONSTRUCTION

A. Operation of air-handling units for temporary cooling, heating, and ventilation is not allowed without Owner authorization.

1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:
 - a. Description of construction activities while units are operating.
 - b. Operation:
 - 1) Beginning and ending calendar dates.
 - 2) List each day during week.
 - 3) List start and stop time and hours for each day.
 - c. Startup procedures and shut-down procedures.

- d. Provisions for routine monitoring of unit operation.
 - e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage and current and electrical fault.
 - f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
 - g. Record keeping.
2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least **[two]<Insert number>** years after the warranty indicated expires.
 3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner.

B. Filtration During Temporary Use:

1. Protect air-handling system ducts (exhaust air, outdoor air, and return air) with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV **[8][11][13]<Insert MERV>** in accordance with ASHRAE 52.2.
2. Protect air-handling units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and by-pass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV **[8][11][13]<Insert MERV>** in accordance with ASHRAE 52.2.
3. Do not operate air-handling units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
4. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting and balancing.

C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.13 DEMONSTRATION

- A. Engage air-handling unit manufacturer **[employed training instructor][or][factory-authorized service representative]** to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.
- B. Training shall include, but not be limited to, procedures and schedules related to performance, safety, startup and shut down, troubleshooting, servicing, preventive maintenance, and how to obtain replacement parts.
 1. Access Doors: Adjustment, gasket removal and replacement, handle removal and replacement, and spare parts.
 2. Access Panels: Removal and replacement, adjustment, gasket removal and replacement, and spare parts.
 3. Air Blenders: Cleaning, operation, removal, and replacement.
 4. Coils: Cleaning, combing fins, draining, venting, removal, and replacement.
 5. Controls: Calibration, cleaning, operation, service, removal and replacement, and spare parts.
 6. Damper Assemblies: Cleaning, operation, service, removal and replacement, and spare parts.
 7. Drain Pans: Cleaning, removal, and replacement.
 8. Duct Silencers: Cleaning, removal, and replacement.
 9. Electric Heaters: Cleaning, operation, service, removal and replacement, and spare parts.
 10. Heat Wheels: Cleaning, operation, service, removal and replacement, and spare parts.



11. Fan and Motor Assemblies: Cleaning, operation, removal and replacement, service, and spare parts.
12. Filters: Operation, removal and replacement, frame gasket removal and replacement, clip removal and replacement, and spare parts.
13. Fixed Plate heat Exchangers: Cleaning, removal, and replacement.
14. Heat Pipe Heat Exchangers: Cleaning, combing fins, removal, and replacement.
15. Humidifiers: Cleaning, operation, service, removal and replacement, and spare parts.
16. UV-C Lamp Systems: Cleaning, operation, service, removal and replacement, and spare parts.
17. Lights, Receptacles and Switches: Cleaning, operation, service, removal and replacement, and spare parts.
18. **<Insert requirement>**.

C. Instructor:

1. Instructor shall be factory trained and certified by air-handling unit manufacturer with current training on equipment installed.
2. Instructor's credentials shall be submitted for review by **[Architect][Commissioning Agent][Owner]** before scheduling training.
3. Instructor(s) **[primary][sole]** job responsibility shall be Owner training.
4. Instructor(s) shall have not less than **[three]<Insert number>** years of training experience with air-handling unit manufacturer and past training experience on at least **[three]<Insert number>** projects of comparable size and complexity.

D. Schedule and Duration:

1. Schedule training with Owner at least **[20]<Insert number>** business days before first training session.
2. Training shall occur before Owner occupancy.
3. Training shall be held at mutually agreed date and time during normal business hours.
4. Each training day shall not exceed **[eight]<Insert number>** hours of training. Daily training schedule shall allow time for a **[one]<Insert number>**-hour lunch period and **[15]<Insert number>**-minute break after every **[two]<Insert number>** hours of training.
5. Perform not less than **[eight][16][24]<Insert number>** hours of training.

E. Location: Owner to provide a suitable on-site location to host classroom training.

F. Training Attendees: Assume **[three]<Insert number>** people.

G. Training Attendance Records: For record purposes, document training attendees at start of each new training session. Record date, time, brief description of training covered during the session, attendee's name, signature, phone number, and e-mail address. Submit scanned copy of sign-in sheet to Owner for each training session.

H. Training Format: Individual training modules to include classroom training followed by hands-on field demonstration and training.

I. Training Materials: Provide training materials in electronic format to each attendee.

1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.

J. Training Video Recording: Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.

K. Written Acceptance: Obtain **[Architect][Commissioning Agent][or][Owner]** written acceptance that



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

training is complete and requirements indicated have been satisfied.

END OF SECTION 23 74 00 00A



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 74 00 00B - DEDICATED OUTDOOR-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Dedicated outdoor-air units.

B. Related Requirements:

1. [Section 284600 "Fire Detection and Alarm."][Section 284614 "Single- and Multiple-Station Alarms."][Section 284600 "Fire Detection and Alarm" and "Section 284614 "Single- and Multiple-Station Alarms."]

1.2 DEFINITIONS:

- A. ECM: Electronically commutated motor.
- B. IS COP: Integrated Seasonal Coefficient of Performance.
- C. ISMRE: Integrated Seasonal Moisture Removal Efficiency.
- D. MRC: Moisture Removal Capacity.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - c. Include unit dimensions and weight.
 - d. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - e. Fans:
 - 1) Certified fan-performance curves with system operating conditions indicated.
 - 2) Certified fan-sound power ratings.
 - 3) Fan construction and accessories.
 - 4) Motor ratings, electrical characteristics, and motor accessories.
 - f. Include certified coil-performance ratings with system operating conditions indicated.
 - g. Include filters with performance characteristics.
 - h. Include heat exchangers with performance characteristics.
 - i. Include dampers, including housings, linkages, and operators.

B. Sustainable Design Submittals:

1. Product Data: Showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
5. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
6. Product Data: Provide the following:
 - a. Manufacturer cut sheet indicating water consumption.
 - b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.

C. Shop Drawings: For each dedicated outdoor-air unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For dedicated outdoor-air-unit supports indicated to comply with performance and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators [**seismic restraints**][and][**wind restraints**], and for designing vibration isolation bases.
2. [**Wind**][and][**Seismic**]-Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
3. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor/roof plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Sample Warranty: For manufacturer's warranty.

C. Seismic Qualification Data: Certificates, for dedicated outdoor-air units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Restraint of internal components.

D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in



"Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Source quality-control reports.

F. Startup service reports.

G. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For dedicated outdoor-air units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: **[One]<Insert number>** set(s) for each belt-driven fan.
2. Filters: **[One]<Insert number>** set(s) for each unit.
3. Gaskets: **[One]<Insert number>** set(s) for each access door.

1.7 WARRANTY

- A. Warranty: Manufacturer agrees to replace components of dedicated outdoor-air units that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Dedicated Outdoor-Air-Handling Units: **[Two][Three]<Insert number>** years from date of Substantial Completion.
 2. Warranty Period for Compressors: **[Five]<Insert number>** years from date of Substantial Completion.
 3. Warranty Period for Heat Exchangers: **[Five][10]<Insert number>** years from date of Substantial Completion.
 4. Warranty Period for Rotary Heat Exchangers: **[Five]<Insert number>** years from date of Substantial Completion.
 5. **<Insert components requiring extended warranty>**.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an "NRTL" (nationally recognized testing laboratory), and marked for intended location and application.



- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE 15 and ASHRAE 34 Compliance: For refrigeration system safety.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. ASHRAE 84 Compliance: Comply with capacity ratings for **[heat-wheel][fixed plate]** energy-recovery equipment.
- G. UL Compliance:
 - 1. Electric Coils: Comply with requirements in UL 1995.
- H. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design **[vibration isolation][seismic restraints][and][wind restraints]**.
- I. Seismic Performance: Units are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]**."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- J. Wind-Restraint Performance:
 - 1. See **[Section 230548 "Vibration and Seismic Controls for HVAC][Section 230548.13 "Vibration Controls for HVAC"]** for requirements.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Supply-Air Fan:
 - 1. Type: **[DWDI, backward-inclined centrifugal fan][DWDI, forward-curved centrifugal fan][DWDI, airfoil centrifugal fan][SWSI, airfoil unhooded centrifugal fan]<Insert fan type>**.
 - 2. Class: AMCA 99, Section 14, **[Class I][Class II]**.
 - 3. Airflow: **<Insert cfm (L/s)>**.
 - 4. External Static Pressure: **<Insert inches wg (kPa)>**.
 - 5. Size: **<Insert wheel size>**.
 - 6. Design Fan Speed: **<Insert number>** rpm.
 - 7. Motor Characteristics:
 - a. Horsepower: **<Insert number>** hp.
 - b. Motor Speed: **[Multispeed][ECM][Constant]<Insert number>** rpm.
 - c. Volts: **[120][208][230][460]<Insert number>** V.

- d. Phase: **[Single][Three]**.
 - e. Hertz: 60.
8. Fan Discharge Sound Power, dB:
- a. 1st Octave: **<Insert value>**.
 - b. 2nd Octave: **<Insert value>**.
 - c. 3rd Octave: **<Insert value>**.
 - d. 4th Octave: **<Insert value>**.
 - e. 5th Octave: **<Insert value>**.
 - f. 6th Octave: **<Insert value>**.
 - g. 7th Octave: **<Insert value>**.
 - h. 8th Octave: **<Insert value>**.
- B. Relief (Exhaust)-Air Fan:
- 1. Type: **[DWDI, backward-inclined centrifugal fan][DWDI, forward-curved centrifugal fan][DWDI, airfoil centrifugal fan][SWSI, airfoil unhooded centrifugal fan]<Insert fan type>**.
 - 2. Class: AMCA 99, Section 14, **[Class I][Class II]**.
 - 3. Airflow: **<Insert cfm (L/s)>**.
 - 4. External Static Pressure: **<Insert inches wg (kPa)>**.
 - 5. Design Fan Speed: **<Insert number>** rpm.
 - 6. Motor Characteristics:
 - a. Horsepower: **<Insert number>** hp.
 - b. Motor Speed: **[Multispeed][ECM][Constant]<Insert number>** rpm.
 - c. Volts: **[120][208][230][460]<Insert number>** V.
 - d. Phase: **[Single][Poly]**.
 - e. Hertz: 60.
 - 7. Fan Inlet Sound Power, dB:
 - a. 1st Octave: **<Insert value>**.
 - b. 2nd Octave: **<Insert value>**.
 - c. 3rd Octave: **<Insert value>**.
 - d. 4th Octave: **<Insert value>**.
 - e. 5th Octave: **<Insert value>**.
 - f. 6th Octave: **<Insert value>**.
 - g. 7th Octave: **<Insert value>**.
 - h. 8th Octave: **<Insert value>**.
- C. Condenser-Air Fan:
- 1. Motor Characteristics:
 - a. Horsepower: **<Insert number>** hp.
 - b. Motor Speed: **[Multispeed][ECM][Constant]<Insert number>** rpm.
 - c. Volts: **[120][208][230][460]<Insert value>** V.
 - d. Phase: **[Single][Poly]**.
 - e. Hertz: 60.
- D. Refrigerant Cooling Coil:
- 1. Capacity: **<Insert tons (kW)>**.
 - 2. ISMRE: **<Insert number>**.
 - 3. Condenser Ambient-Air Temperature: **<Insert deg F (deg C)>**.

4. Evaporator Coil:

- a. Sensible Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
- b. Total Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
- c. Entering-Air, Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
- d. Entering-Air, Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
- e. Leaving-Air, Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
- f. Leaving-Air, Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
- g. Face Area: **<Insert sq. ft. (sq. m)>**.
- h. Maximum Face Velocity: **<Insert fpm (m/s)>**.
- i. Maximum Air-Side, Static-Pressure Drop: **<Insert inches wg (Pa)>**.
- j. Fin Spacing: **<Insert fins per inch (cm)>**.
- k. Fin Thickness: **<Insert inches (mm)>**.
- l. Number of Rows: **<Insert number>**.

E. Hot-Gas Reheat Coil:

1. Heating Capacity: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Air-Temperature Rise: **<Insert deg F (deg C)>**.
4. Refrigerant Type: **<Insert refrigerant type>**.

F. Electric-Resistance Heating Coils:

1. Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Power Input: **<Insert number> kW**.
5. Volts: **[120][208][230][480]<Insert number> V**.
6. Phase: **[Single][Three]**.
7. Hertz: 60.
8. Full-Load Amperes: **<Insert number> A**.
9. Maximum Overcurrent Protection: **<Insert number> A**.
10. Capacity Control: Number of Steps or SCR: **<Insert number or SCR>**.

G. Gas-Fired Furnace Heating:

1. Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Efficiency: **[80]<Insert number> percent**.
5. Fuel: **[Natural][Propane] gas**.
6. Burner: **[Modulating][Staged]**.
7. Turndown Ratio: Minimum **[5:1][6:1][8:1]<Insert ratio>**.
8. Gas Heating Value: **<Insert Btu/cu. ft. (kJ/L)>**.
9. Gas Input: **<Insert cfh (mL/s)>**.
10. Gas Burner Electrical Characteristics:
 - a. Power Input: **<Insert number> kW**.
 - b. Volts: **[120][208][230][460]<Insert number> V**.
 - c. Phase: **[Single][Three]**.
 - d. Hertz: 60.
 - e. Full-Load Amperes: **<Insert number> A**.
 - f. Minimum Circuit Ampacity: **<Insert number> A**.
 - g. Maximum Overcurrent Protection: **<Insert number> A**.

H. Heating Coils: **[Hot Water][Steam]**.

1. Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Face Area: **<Insert sq. ft. (sq. m)>**.
5. Maximum Face Velocity: **<Insert fpm (m/s)>**.
6. Maximum Air-Side, Static-Pressure Drop: **<Insert inches wg (Pa)>**.
7. Coil Type: **[Continuous circuit][Self-draining][Cleanable][Distributing][Single tube]**.
8. Piping Connections: **[Threaded][Flanged]; [same end][opposite ends]** of coil.
9. Tube Thickness: **<Insert inches (mm)>**.
10. Fin Spacing: **<Insert fins per inch (cm)>**.
11. Fin Thickness: **<Insert inches (mm)>**.
12. Number of Rows: **<Insert number>**.
13. Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value>**.
14. Fluid Flow: **<Insert gpm (L/s)>**.
15. Maximum Fluid-Pressure Drop: **<Insert feet of head (kPa)>**.
16. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
17. Leaving-Fluid Temperature: **<Insert deg F (deg C)>**.
18. Fluid Velocity: **<Insert fpm (L/s)>**.
19. Steam Flow: **<Insert lb/h (g/s)>**.
20. Inlet Steam Pressure: **<Insert psig (kPa)>**.

I. Rotary Heat Exchanger:

1. Effectiveness: **<Insert number>** percent.
2. Intake Airflow: **<Insert cfm (L/s)>**.
3. Pressure Differential: **<Insert inches wg (kPa)>**.
4. Entering Supply-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
5. Entering Supply-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
6. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
7. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
8. Relief/Exhaust Airflow: **<Insert cfm (L/s)>**.
9. Entering Relief/Exhaust-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
10. Entering Relief/Exhaust-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
11. Leaving Relief/Exhaust-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
12. Leaving Relief/Exhaust-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.

J. Filters:

1. Type: **[Panel]<Insert type>**.
2. Face Dimensions, Each: **<Insert inches by inches (mm by mm)>**.
3. Depth: **<Insert inches (mm)>**.
4. Number of Filters in Filter Bank: **<Insert number>** wide by **<Insert number>** high.
5. Access Location: **[Side]<Insert location>**.
6. Maximum or Rated Face Velocity: **<Insert fpm (m/s)>**.
7. Initial Resistance: **<Insert inches wg (Pa)>**.
8. Recommended Final Resistance: **<Insert inches wg (Pa)>**.
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating and Corresponding Average Arrestance: **[MERV 1][MERV 2][MERV 3][MERV 4]**, and corresponding average arrestance, in accordance with ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 8][MERV 11][MERV 13][MERV 14]<Insert value>**, in

accordance with ASHRAE 52.2.

K. Electrical Characteristics for Single-Point Connection:

1. Volts: [120][208][230][460]<Insert number> V.
2. Phase: [Single][Three].
3. Hertz: 60.
4. Full-Load Amperes: <Insert number> A.
5. Minimum Circuit Ampacity: <Insert number> A.
6. Maximum Overcurrent Protection: <Insert number> A.

2.3 DEDICATED OUTDOOR-AIR UNITS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [AAON]
2. [Addison]
3. [Desert Aire]
4. [Munters Corporation]
5. [REZNOR, a brand of Nortek Global HVAC]
6. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [AAON]
2. [Addison]
3. [Desert Aire]
4. [Munters Corporation]
5. [REZNOR, a brand of Nortek Global HVAC]
6. <Insert manufacturer's name>

C. Source Limitations: Obtain dedicated outdoor-air units from single manufacturer.

D. Unit Casing:

1. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
2. Configuration: Horizontal unit with [top][horizontal][bottom] discharge for [roof-mounting][concrete-base] installation.
3. Double-Wall Configuration:
 - a. Outside Casing Wall: [Galvanized steel][Stainless steel][, stainless steel in cooling coil section]<Insert material>, minimum [18 gauge (1.3 mm)]<Insert value> thick with [manufacturer's standard finish][corrosion-resistant coating]<Insert special coating>, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
 - b. Inside Casing Wall:
 - 1) Inside Casing, Burner Section: [Galvanized steel]<Insert material>, solid, minimum [14-gauge- (0.759-mm-)]<Insert value> thick steel.

- 2) Inside Casing, All Other Sections: **[Galvanized steel]<Insert material>, [solid][perforated].**
- 3) Antimicrobial Coating: Applied during the manufacturing process. Coating is to be **[EPA approved][NSF approved][FDA listed].**
- c. Floor Plate: Reinforced metal surface; reinforced to limit deflection when walked on by service personnel. Insulation is provided below metal walking surface.
- d. Roof: Standing seam or membrane; sloped to drain water.
- e. Casing Insulation:
 - 1) Materials: Polyurethane foam insulation.
 - 2) Casing Panel R-Value: Minimum **[R-6.5][R-11][R-13]<Insert value>.**
 - 3) Insulation Thickness: **[1 inches (25 mm)][2 inches (50 mm)]<Insert dimension>.**
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
4. Airstream Surfaces: Surfaces in contact with airstream are to comply with requirements in ASHRAE 62.1.
5. Static-Pressure Classifications:
 - a. For Unit Sections Upstream of Fans: Minus **[2 inches wg (500 Pa)][3 inches wg (750 Pa)]<Insert value>.**
 - b. For Unit Sections Downstream and Including Fans: **[2 inches wg (500 Pa)][3 inches wg (750 Pa)][4 inches wg (1000 Pa)]<Insert value>.**
6. Panels and Doors:
 - a. Panels:
 - 1) Fabrication: Formed and reinforced double-wall and insulated panels of same materials and thicknesses as casing.
 - 2) Fasteners: Two or more camlock-type fasteners for panel lift-out operation. Arrangement is to allow panels to be opened against airflow.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.
 - b. Doors:
 - 1) Fabrication: Formed and reinforced double-wall and insulated panels of same materials and thicknesses as casing.
 - 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.
 - c. Locations and Applications:
 - 1) Fan Section: **[Panels][Doors].**
 - 2) Access Section: Doors.
 - 3) Gas-Fired Burner Section: **[Panels][Doors].**
 - 4) Damper Section: **[Panels][Doors].**
 - 5) Filter Section: **[Panels][Doors]** large enough to allow periodic removal and

- 6) installation of filters.
- 6) Relief Section: Doors.

7. Condensate Drain Pans:

- a. Location: Each refrigerant coil[**and rotary heat exchanger**].
- b. Construction:
 - 1) Single-wall, [**galvanized-steel or noncorrosive polymer**][**stainless steel**] sheet.
- c. Size: Large enough to collect condensate from cooling coils, including coil piping connections, coil headers, and return bends.
- d. Drain Connection:
 - 1) Located on [**one end**][**both ends**] of pan, at lowest point of pan.
 - 2) Terminated with threaded nipple.
 - 3) Minimum Connection Size: [**NPS 1 (DN 25)**][**NPS 2 (DN 50)**]**<Insert pipe size>**.
- e. Slope: Minimum [**0.125-inch/ft. (10-mm/m)**]**<Insert value>** slope[, **to comply with ASHRAE 62.1,**] in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
- f. Length: Extend drain pan downstream from leaving face [**for distance to comply with ASHRAE 62.1**]**<Insert distance>**.
- g. Width: Entire width of water-producing device.
- h. Depth: A minimum of [**2 inches (50 mm)**]**<Insert dimension>** deep.
- i. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
- j. Provide units having stacked coils with intermediate drain pan to collect condensate from top coil.

E. Fans, Drives, And Motors:

- 1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- 2. Supply-Air Fans and Relief-Air Fans: Centrifugal; galvanized or painted steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway.
 - b. Shaft Bearings:
 - 1) Heavy-duty, self-aligning, pillow-block type with an [**L-50**]**<Insert bearing life rating>** rated life of minimum [**100,000**]**<Insert number>** hours in accordance with ABMA 9.
 - c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - 1) Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 - d. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute

- housing. Provide inlet screens for Type SWSI fans.
 - e. Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; **[steel][aluminum]** hub riveted to backplate and fastened to shaft with setscrews.
 - f. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; **[steel][aluminum]** hub swaged to backplate and fastened to shaft with setscrews.
 - g. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
 - h. Mounting: For internal vibration isolation **[and seismic control]**. Factory mount fans with manufacturer's standard **[restrained]** vibration isolation mounting devices having a minimum static deflection of **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>**.
 - i. Shaft Lubrication Lines: Extended to a location outside the casing.
 - j. Flexible Connector: Factory fabricated with a fabric strip minimum **3-1/2 inches (89 mm) <Insert dimension>** wide, attached to two strips of minimum **2-3/4-inch- (70-mm-) wide <Insert width>** by **0.028-inch- (0.7-mm-) thick, galvanized-steel sheet**.
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives are to comply with UL 181, Class 1.
3. Drive, Direct: Factory-mounted direct drive.
4. Drive, Belt: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with **[1.5][1.25]** service factor based on fan motor.
- a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, nonsparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards"; **[0.146 inch (2.7 mm)]<Insert dimension>** thick, **[3/4-inch (20-mm)]<Insert dimension>** diamond-mesh wire screen, welded to steel angle frame; prime coated.
5. Condenser-Coil Fan: **[Variable-speed]**propeller, mounted on shaft of permanently lubricated **[multispeed][electronically commutated]** motors.
6. Motors:
- a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 - d. Enclosure Materials: **[Cast iron]<Insert material>**.
 - e. Motor Bearings: **<Insert requirements>**.
 - f. Unusual Service Conditions:
 - 1) Ambient Temperature: **<Insert deg C (deg C)>**.
 - 2) Altitude: **<Insert feet (m)>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
 - g. Efficiency: Premium efficient as defined in NEMA MG 1.
 - h. NEMA Design: **<Insert designation>**.
 - i. Motor Pulleys: Adjustable pitch for use with **[5]<Insert number>** hp motors and smaller;

- fixed pitch for use with motors larger than [5]<Insert number> hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
- j. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - k. <Insert unique motor characteristics>.
 - l. Mount unit-mounted disconnect switches on [exterior][interior] of unit.
7. Comply with Section 262923 "Variable-Frequency Motor Controllers."
 8. Variable-Frequency Motor Controller: Serving [each fan individually][all fans combined] in fan array.
 - a. Manufactured Units: Pulse-width modulated; [constant torque][and][variable torque]<Insert application> for [Design A and Design B][inverter-duty] motors.
 - b. Output Rating: Three phase; 10 to [60 Hz, with voltage proportional to frequency throughout voltage range][66 Hz, with torque constant as speed changes]; maximum voltage equals input voltage.
 - c. Unit Operating Requirements:
 - 1) Internal Adjustability:
 - a) Minimum Speed: 5 to 25 percent of maximum rpm.
 - b) Maximum Speed: 80 to 100 percent of maximum rpm.
 - c) Acceleration: [0.1 to 999.9]<Insert range> seconds.
 - d) Deceleration: [0.1 to 999.9]<Insert range> seconds.
 - e) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - 2) Self-Protection and Reliability Features:
 - a) Surge suppression.
 - b) Loss of input signal protection.
 - c) Under- and overvoltage trips.
 - d) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - e) Critical frequency rejection.
 - f) Loss-of-phase protection.
 - g) Reverse-phase protection.
 - h) Motor-temperature fault.
 - 3) Bidirectional autospeed search.
 - 4) Torque boost.
 - 5) Motor temperature compensation at slow speeds.
 - a) Panel-mounted operator station.
 - b) Historical logging information and displays.
 - c) Digital indicating devices.
 - 6) Control Signal Interface: Electric.
 - 7) Proportional Integral Directive (PID) control interface.
 - 8) DDC system for HVAC Protocols for Network Communications: [ASHRAE 135]<Insert protocol type>.
 - d. Line Conditioning:
 - 1) Input line conditioning.
 - 2) Output filtering.

3) EMI/RFI filtering.

e. Bypass Systems:

- 1) Bypass Mode: **[Manual operation only][Field-selectable automatic or manual]**.
- 2) Bypass Controller, Two-Contactor Style: With bypass and output isolating contactors **[and isolating switch]**.
- 3) Bypass Controller, Three-Contactor Style: With bypass and input and output isolating contactors **[and isolating switch]**.
- 4) Bypass Contactor Configuration: **[Full-voltage (across the line)][Reduced-voltage (autotransformer)]<Insert type>** type.

F. Coils:

1. General Requirements for Coils:

- a. Comply with AHRI 410.
- b. Fabricate coils section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
- c. Coils are not to act as structural component of unit.

2. Supply-Air Refrigerant Coils:

- a. Tubes: **[Copper]<Insert material>**.
- b. Fins:
 - 1) Material: **[Aluminum][Copper]<Insert material>**.
 - 2) Fin Spacing: Maximum **[12][10][8]<Insert spacing>** fins per inch (mm).
- c. Fin and Tube Joints: Mechanical bond.
- d. Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
- e. Frames: **[Galvanized steel]<Insert material frame>**.
- f. Coatings: **[None][Corrosion-resistant coating]**.
- g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum **300 psig (2070 kPa)**.

3. Hot-Gas Reheat Refrigerant Coils:

- a. Tubes: **[Copper]<Insert material>**.
- b. Fins:
 - 1) Material: **[Aluminum][Copper]<Insert material>**.
 - 2) Fin Spacing: Maximum **[12][10][8]<Insert spacing>** fins per inch (mm).
- c. Fin and Tube Joints: Mechanical bond.
- d. Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
- e. Frames: **[Galvanized steel][Stainless steel]<Insert material frame>**.
- f. Coatings: **[None][Corrosion-resistant coating]**.
- g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum **300 psig (2070 kPa)**.
- h. Coating: **[None][Corrosion-resistant coating]**.

- i. Suction-discharge bypass valve.
4. Electric-Resistance Heating Coils: Comply with UL 1995.
 - a. Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
 - b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 - d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 - e. Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - 1) Magnetic contactor.
 - 2) Solid-state, stepless pulse controller.
 - 3) Toggle switches, one per step.
 - 4) **[Step][SCR]** controller.
 - 5) Time-delay relay.
 - 6) Pilot lights, one per step.
 - 7) Airflow proving switch.
5. Heating-Water Coils: **[Continuous circuit][Self-draining][Cleaning]**.
 - a. Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - b. Tube Material: **[Copper]<Insert material>**.
 - c. Fin Type: Plate.
 - d. Fin Material: **[Aluminum][Copper]<Insert material>**.
 - e. Fin Thickness: **<Insert inches (mm)>**.
 - f. Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - g. Headers:
 - 1) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.
 - 2) Seamless copper tube with brazed joints, prime coated.
 - 3) Fabricated steel, with brazed joints, prime coated.
 - 4) Provide insulated cover to conceal exposed outside casings of headers.
 - 5) Frames: Channel frame, minimum **0.052-inch (1.3-mm)** thick galvanized steel.
 - 6) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
 - h. Coating: **[None][Corrosion-resistant coating]**.
6. Steam Heating Coils:
 - a. Steam Coils: **[Distributed][Single tube]**.
 - 1) Steam Outer-Tube Diameter: **<Insert inches (mm)>**.
 - 2) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 3) Tube Material: **[Copper]<Insert material>**.
 - 4) Fin Type: Plate.
 - 5) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 6) Fin Thickness: **<Insert inches (mm)>**.
 - 7) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.

- 8) Headers:
 - a) Cast iron with[**cleaning plugs and**] drain and air vent tappings[**extended to exterior of unit**].
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
- 9) Frames: Channel frame, minimum **0.052-inch (1.3-mm)** thick galvanized steel.
- 10) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
- 11) Coating: **[None][Corrosion-resistant coating]**.

7. Condenser Refrigerant Coils:

- a. Tube Material: **[Copper]<Insert material>**.
- b. Fin Material: **[Aluminum][Copper]**.
- c. Fin and Tube Joint: Mechanical bond.
- d. Coating: **[None][Corrosion-resistant]**.

G. Refrigeration Circuit Components:

1. Compressors: Hermetic, **[variable-speed]** scroll compressors, mounted on integral vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief[, and **crankcase heater**].
2. Refrigerant: **[R-410A]<Insert other available type>**.
3. Refrigeration Specialties:
 - a. Expansion valve with replaceable thermostatic element.
 - b. Refrigerant filter/dryer.
 - c. Manual-reset high-pressure safety switch.
 - d. Automatic-reset low-pressure safety switch.
 - e. Minimum off-time relay.
 - f. Automatic-reset compressor motor thermal overload.
 - g. Thermostat for coil freeze-up protection during low-ambient-temperature operation or loss of air.
 - h. Brass service valves installed in discharge and liquid lines.
 - i. Low-ambient kit high-pressure sensor.
 - j. Single compressor with evaporator and condenser coil within the refrigerant section to provide initial pre-cooling and to reheat for humidity control.
 - k. **[Single stage][Modulating]** hot-gas reheat solenoid valve with a replaceable magnetic coil.
 - l. Heat-pipe heat exchanger, wrapped around the evaporator coil to pre-cool the air entering the evaporator coil and reheat the air leaving the evaporator coil to control humidity.
 - m. Hot-gas bypass refrigerant control for capacity control with continuous dehumidification for single-speed compressor.

H. Air Filtration:

1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
2. Panel Filters:
 - a. Description: **[Flat, nonpleated][Pleated]** factory-fabricated, self-supported disposable air filters with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive and

- antimicrobial coating.
 - d. Filter-Media Frame: [**High wet-strength beverage board**]<Insert material> with perforated metal retainer, or metal grid, on outlet side.
 - I. Adhesive: As recommended by air-filter manufacturer and with a VOC content of [**80**]<Insert number> g/L or less.
 - 1. Mounting Frames:
 - a. Panel filters arranged for flat or angular orientation, with access doors on both sides of unit. Filters are to be removable from one side or from access plenum.
 - b. Cartridge filters arranged for flat orientation, removable from access plenum.
 - c. Galvanized or stainless steel with gaskets and fasteners, suitable for bolting together into built-up filter banks[**with space for prefilter**].
 - J. Rotary Heat Exchanger:
 - 1. Casing:
 - a. Galvanized steel, stainless steel, or aluminum with manufacturer's standard factory-painted finish.
 - b. Integral purge section limiting carryover of exhaust air to between [**0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa)**]<Insert values> differential pressure.
 - c. Casing seals on periphery of rotor and on duct divider and purge section.
 - d. Support vertical rotor on grease-lubricated ball bearings having extended grease fittings[**or permanently lubricated bearings**]. Support horizontal rotors on tapered roller bearings.
 - 2. Rotor - Aluminum, Metallic, or Polymer: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.
 - 3. Drive: Fractional horsepower motor and gear reducer[, **with speed changed by variable-frequency controller**]. Provide permanently lubricated wheel bearings.
 - 4. Controls:
 - a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
 - b. Variable-frequency controller, factory mounted and wired, permitting input of 4-20 mA or 1-10 V control signal.
 - c. Control energy recovery to permit air economizer operation.
 - 1) Bypass dampers to assist energy recovery control.
 - d. Pilot-Light Indicator: Display rotor rotation and speed.
 - e. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
 - f. Integral purge section limiting carryover of exhaust air to between [**0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa)**]<Insert value> differential pressure.
 - g. Defrost cycle.
 - h. <Insert additional control features>.
 - K. Indirect-Fired Gas Furnace Heating:
 - 1. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.
 - 2. CSA Approval: Designed and certified by and bearing label of CSA.

3. Burners:
 - a. Heat-Exchanger Material: **[Aluminized steel with stainless steel inserts][Stainless steel]**.
 - b. Fuel: **[Natural][Propane]** gas.
 - c. Ignition: Electronically controlled electric spark with flame sensor.
 - d. Gas Control Valve: **[Single stage][Two stage][Electronic modulating]**.
 - e. Gas Train: Single-body, regulated, redundant, 24 V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.
 - f. High-Altitude Model Kit: For Project elevations of more than **2000 feet (610 m)** above sea level.
4. Venting, Gravity: Gravity vented.
5. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.
6. Heat-Exchanger Drain Pan: Stainless steel.
7. Safety Controls:
 - a. Gas Manifold: Safety switches and controls complying with ANSI standards **[and][FM Global]<Insert insurer>**.
 - b. Vent Flow Verification: **[Differential pressure switch to verify open vent][Flame rollout switch]**.
 - c. High Limit: Thermal switch or fuse to stop burner.
 - d. Purge-period timer is to automatically delay burner ignition and bypass low-limit control.
 - e. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
 - f. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - g. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
- L. Dampers:
 1. Comply with requirements in Section 230923.12 "Control Dampers."
 2. Outdoor- and Relief-Air Dampers: Low-leakage, double-skin, airfoil-blade, **[galvanized-steel]<Insert material>** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **[opposed][parallel]**-blade arrangement with **[zinc-plated]** steel operating rods rotating in **[sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel]<Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate is not to exceed **4 cfm/sq. ft. (20 L/s per sq. m)** at **1 inch wg (250 Pa)** and **8 cfm/sq. ft. (40 L/s per sq. m)** at **4 inches wg (1.0 MPa)**.
 3. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
 4. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator is to have visual scale indicating percentage of travel and 2 to 10 V dc feedback signal.
 - c. Operator Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit

switches, auxiliary switches, or feedback potentiometer.

- d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
- e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
- f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft. (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with 2 to 3 Inches wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3 to 4 Inches wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
- g. Coupling: V-bolt and V-shaped, toothed cradle.
- h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
- i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
- j. Power Requirements (Two-Position Spring Return): **[24 V dc][120 V ac][230 V ac]**.
- k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
- l. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2 to 10 V dc position feedback signal.
- m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.
- n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.

M. Electrical Power Connections:

1. Single-Point Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices are to provide a **[single-point]field power connection to unit [except for service lights and convenience outlets, which are to be powered separately]**.
2. Enclosure: NEMA 250, **[Type 3R][Type 4][Type 4X]<Insert type>**, mounted in unit with hinged access door in unit cabinet having a lock and key or padlock and key.
3. Wiring: Numbered and color-coded to match wiring diagram.
4. Wiring Location: Install factory wiring outside an enclosure in a raceway.
5. Power Interface: Field power interface to be **[wire lugs][NEMA KS 1, heavy-duty, nonfused disconnect switch]**.
6. Factory Wiring: Branch power circuit to each motor and to controls with one of the following disconnecting means:
 - a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.
 - b. NEMA KS 1, heavy-duty, nonfusible switch.
 - c. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
7. Factory-Mounted, Overcurrent-Protection Service: For each motor.

8. Transformer: Factory mounted with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
9. Controls: Factory wire unit-mounted controls where indicated.
 - a. Service Lights: **<Insert number of watts>[LED]<Insert lamp type>** vaporproof luminaire with individual switched junction box located **[outside][inside]**, adjacent to each access door and panel.
 - 1) Locations: **[Each section accessed with door or panel][Fan section]<Insert location>**.
 - b. Convenience Outlets: One 20 A duplex GFCI receptacle per location with junction box located on outside casing wall.
 - 1) Locations: **[Each section accessed with a door or panel][Fan section]<Insert location>**.
10. Control Relays: Auxiliary and adjustable time-delay relays.

N. Controls:

1. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.
2. Control Valves: Comply with requirements in Section 230923.11 "Control Valves."
3. Control Wiring: Factory wire connection for controls' power supply.
4. Control Devices: Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves are to be manufacturer's standard items to accomplish indicated control functions.
5. Status Panel: **[Remote][Unit]** mounted.
 - a. Cooling/Off/Heating Controls: Control operational mode.
 - b. Damper Position: Indicate position of outdoor-air dampers in terms of percentage of outdoor air.
 - c. Status Lights:
 - 1) Filter dirty.
 - 2) Fan operating.
 - 3) Cooling operating.
 - 4) Heating operating.
 - 5) Smoke alarm.
 - 6) General alarm.
 - 7) **<Insert points>**.
 - d. Digital Numeric Display:
 - 1) Outdoor airflow.
 - 2) Supply airflow.
 - 3) Outdoor dry-bulb temperature.
 - 4) Outdoor dew point temperature.
 - 5) Space temperature.
 - 6) Supply temperature.
 - 7) Space relative humidity.
 - 8) Space carbon dioxide level.
 - 9) **<Insert points>**.
6. Refrigeration System Controls:

- a. Unit-mounted enthalpy controller is to lock out refrigerant system when outdoor-air enthalpy is less than **[28 Btu/lb (65 kJ/kg)]<Insert value>** of dry air or outdoor-air temperature is less than **60 deg F (15 deg C) <Insert value>**.
 - b. Outdoor-air sensor de-energizes dehumidifier operation when outdoor-air temperature is less than **60 deg F (15 deg C) <Insert value>**.
 - c. Relative-humidity sensor energizes dehumidifier operation when relative humidity is more than **[50]<Insert value>** percent.
7. Furnace Controls:
 - a. **[Factory-mounted sensor in supply outlet][Remote sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to modulate gas furnace burner to maintain space temperature.
 - b. Wall-mounted, space-temperature sensor with **[temperature adjustment][unit-mounted temperature adjustment][adjustment on remote-control panel]** to modulate gas furnace burner to maintain space temperature.
 - c. Remote Setback: Adjustable room thermostat selected by timer, set at **[50 deg F (10 deg C)]<Insert temperature>**; cycles supply fan and gas furnace burner to maintain space temperature.
 - d. Burner Control: **[Two][Four][steps of control][Modulating]**.
8. Rotary Heat-Exchanger Control:
 - a. Sequence with refrigeration system controls and heating controls.
 - b. For operation of rotary heat exchanger itself, see "Rotary Heat Exchanger" Paragraph above.
9. Electric-Resistance Heat Controls:
 - a. **[Factory-mounted sensor in unit discharge][Remote sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to control electric coil to maintain temperature.
 - b. Wall-mounted, space-temperature sensor with **[temperature adjustment][unit-mounted temperature adjustment][adjustment on remote-control panel]** to control electric coil to maintain temperature.
 - c. Capacity Controls: **[On/off][Multiple steps][Modulating SCR]<Insert type>**.
10. Hot-Water and Steam Coil Controls, Discharge Temperature Sensor: **[Factory-mounted sensor in unit discharge][Remote sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to modulate factory-**[mounted][furnished]** coil control valve to maintain temperature.
11. Hot-Water and Steam Coil Controls, Space Temperature Sensor: With **[temperature adjustment][unit-mounted temperature adjustment][adjustment on remote-control panel]** to modulate factory-**[mounted][furnished]** coil control valve to maintain temperature.
12. Damper Controls: Space-pressure sensor modulates outdoor- and relief-air dampers to maintain a positive pressure in space at a minimum of **[0.05 inch wg (12.4 Pa)]<Insert value>** with respect to outdoor reference.
13. DDC Temperature Control: Standalone control module for link between unit controls and DDC temperature-control system. Control module is to be compatible with control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Links are to include the following:
 - a. Start/stop interface relay and relay to notify DDC temperature-control system alarm condition.
 - b. Hardware interface or additional sensors for the following:

- 1) Room temperature.
 - 2) Discharge-air temperature.
 - 3) Refrigeration system operation.
 - 4) Furnace operation.
14. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display unit status and alarms.
- a. Hardwired Points:
 - 1) Monitoring: On-off status, **[common trouble alarm]<Insert monitoring point>**.
 - 2) Control: On-off operation, **[space temperature set-point adjustment][supply temperature set-point adjustment][space humidity set-point adjustment][space pressure set-point adjustment]<Insert control point>**.
 - b. **[ASHRAE 135 (BACnet)][LonTalk][Modbus][Industry-accepted, open-protocol]<Insert type of interface>** communication interface with the DDC system for HVAC is to enable the DDC system for HVAC operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel are to be available through the DDC system for HVAC.
15. **<Insert additional control sequences and requirements>**.
- O. Roof Curbs:
1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC." Roof curbs with vibration isolators and wind restraints are specified in Section 230548.13 "Vibration Controls for HVAC."
 2. Materials: Galvanized steel with corrosion-resistant coating, watertight gaskets, and factory-installed wood nailer; complying with National Roofing Contractors Association manuals for the specific type of roofing applicable to the Project.
 - a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1) Materials: ASTM C1071, Type I or II.
 - 2) Thickness: **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension>**.
 - b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C916, Type I.
 - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - 3) Liner materials applied in this location are to have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service air velocity.
 3. Curb Dimensions: Height of **[14 inches (355 mm)][24 inches (610 mm)][36 inches (910 mm)]<Insert dimension>**. **[Provide adaptable horizontal dimensions as required for existing roof openings.]**
 4. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.

P. Intake And Relief Openings:

1. Type: Manufacturer's standard hood or louver, including moisture eliminator, at all unit intake and relief openings.
2. Materials: Match material and finish of casing exterior.
3. Bird Screen: Comply with requirements in ASHRAE 62.1.
4. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.4 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: **ASTM B209 (ASTM B209M)**.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat **[casing][coils][and][fan guards]** with a corrosion-resistant coating capable of withstanding a **[3,000]<Insert time>**-hour salt-spray test in accordance with ASTM B117.

1. Standards:

- a. ASTM B117 for salt spray.
- b. ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
- c. ASTM D3359 for cross-hatch adhesion of 5B.

2. Application: **[Immersion][Spray]**.

3. Thickness: **[1 mil]<Insert measurement>**.

4. Gloss: Minimum gloss of 50 gloss units on a single angle 60-degree meter.

2.5 SOURCE QUALITY CONTROL

- A. AHRI 920: Manufacturer to certify that performance ratings are in accordance with AHRI 920 if AHRI 920 certification program is not in place. Provide AHRI 920 certification if AHRI 920 certification program is in place.
- B. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label unit fan sound ratings in accordance with AHRI 260 or AMCA 311.
- C. Fan Aerodynamic Performance Rating: Test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency.

1. **[Test and rate fan performance in accordance with AMCA 210.]**
2. **[AMCA Fan Aerodynamic Certification Rating: Test, rate, and label, in accordance with AMCA 211.]**
- D. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- E. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- F. Damper Leakage and Air Performance:
 1. **[Damper Rating: Test and rate dampers for leakage and air performance in accordance with AMCA 510.]**
 2. **[AMCA Damper Certification: Test, rate, and label in accordance with AMCA 511.]**
- G. Water Coils: Factory tested to **300 psig (2070 kPa)** in accordance with AHRI 410 and ASHRAE 33.
- H. Refrigerant Coils: Factory tested to minimum **[300 psig (2070 kPa)][450 psig (3105 kPa)]** internal pressure and to minimum **300 psig (2070 kPa)** internal pressure while under water, in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF DEDICATED OUTDOOR-AIR UNITS

- A. Roof Curb: Install on roof structure or concrete base, level and secure, in accordance with **[NRCA's "The NRCA Roofing Manual: Membrane Roof Systems"]****[AHRI Guideline B]****<Insert reference document>**. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
- B. Unit Support: Install unit level on structural **[curbs]****[steel supports]**. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of **[curbs]****[steel supports]** with actual equipment provided.
 1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."



- C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- F. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.
- G. Comply with requirements for gas-fired furnace installation in NFPA 54.
- H. Install separate devices furnished by manufacturer and not factory installed.
- I. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to units, allow space for service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Hot-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- E. Steam and Steam Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and provide inverted bucket steam trap at condensate return connection.
- F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.
- G. Gas Piping: Comply with requirements in **[Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping."]** Provide AGA-approved flexible connectors.
 - 1. Connect gas piping to furnace, full size of gas train inlet, and connect with union[, **pressure regulator,**] and shutoff valve with sufficient clearance for burner removal and service.
 - 2. Install AGA-approved flexible connectors.
- H. Hydronic Piping Connections:
 - 1. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 2. Install shutoff valve and union or flange on each supply connection, and install balancing valve

and union or flange on each return connection.

I. Steam Piping Connections:

1. Comply with requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
2. Install shutoff valve and union or flange on each supply connection.
3. Install, starting from the coil connection, union or flange, strainer, union, float and thermostatic trap, union, and shutoff valve.

J. Duct Connections:

1. Comply with requirements in Section 233113 "Metal Ducts."
2. Drawings indicate the general arrangement of ducts.
3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Inspect units for visible damage to furnace combustion chamber.
 3. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.

- c. Measure flue-gas temperature at furnace discharge.
 - d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
4. Verify operation of remote panel, including pilot-light operation and failure modes. Inspect the following:
 - a. High-limit heat exchanger.
 - b. Alarms.
5. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
6. Start refrigeration system when outdoor-air temperature is within normal operating limits. and measure and record the following:
 - a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
 - b. Cooling coil entering-air, dry- and wet-bulb temperatures.
 - c. Condenser coil entering-air dry-bulb temperature.
 - d. Condenser coil leaving-air dry-bulb temperature.
7. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.
8. Inspect casing insulation for integrity, moisture content, and adhesion.
9. Verify that clearances have been provided for servicing.
10. Verify that controls are connected and operable.
11. Verify that filters are installed.
12. Clean coils and inspect for construction debris.
13. Clean furnace flue and inspect for construction debris.
14. Inspect operation of power vents.
15. Purge gas line.
16. Inspect and adjust vibration isolators and seismic restraints.
17. Verify bearing lubrication.
18. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
19. Adjust fan belts to proper alignment and tension.
20. Start unit.
21. Inspect and record performance of interlocks and protective devices, including response to smoke detectors by fan controls and fire alarm.
22. Operate unit for run-in period.
23. Calibrate controls.
24. Adjust and inspect high-temperature limits.
25. Inspect outdoor-air dampers for proper stroke[**and interlock with return-air dampers**].
26. Verify operational sequence of controls.
27. Measure and record the following airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Relief-air flow.
 - c. Outdoor-air flow.

- B. After startup, change filters, verify bearing lubrication, and adjust belt tension.

- C. Remove and replace components that do not properly operate, and repeat startup procedures as specified above.
- D. Prepare written report of the results of startup services.

3.7 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.8 CLEANING

- A. After completing system installation; testing, adjusting, and balancing dedicated outdoor-air unit and air-distribution systems; and completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, casings, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
 - 2. Charge refrigerant coils with refrigerant and test for leaks.
 - 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 23 74 00 00B



THIS PAGE INTENTIONALLY LEFT BLANK



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 74 16 00	23 74 00 00	Outdoor, Semi-Custom Air-Handling Units
23 74 16 00	23 74 00 00a	Outdoor, Custom Air-Handling Units
23 74 16 00	23 74 00 00b	Dedicated Outdoor-Air Units



THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 74 16 13 - PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, large-capacity, rooftop air-conditioning units.

B. Related Requirements:

1. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components.

1.2 DEFINITIONS

- A.** RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, large-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.3 ACTION SUBMITTALS

A. Product Data: For each RTU.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include gas furnaces with performance characteristics.
9. Include factory selection calculations for each antimicrobial UV lamp installation.
10. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each packaged, large-capacity, rooftop air-conditioning unit.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittals: For RTU supports, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Restraint Details: [**Wind-**][**and**][**seismic-**]detail fabrication and attachment of[**wind and**] seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

D. Sustainable Design Submittals:

1. Product Data: Showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance. Comply with efficiency requirements in IgCC/ASHRAE 189.1, which supersede requirements in ASHRAE/IES 90.1.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
5. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
6. Laboratory Test Reports: For adhesives and sealants, indicating compliance with requirements for low-emitting materials.
7. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
8. Product Data: For refrigerants, indicating compliance with refrigerant management practices.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for RTUs, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Restraint of internal components.

C. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- D. Source quality control reports.
- E. System startup reports.
- F. Field quality control reports.
- G. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For RTUs.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: **[One]<Insert number>** set(s) of filters for each unit.
 - 2. Gaskets: **[One]<Insert number>** set(s) for each access door.
 - 3. Fan Belts: **[One]<Insert number>** set(s) for each belt-driven fan.

1.7 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of packaged, large-capacity, rooftop air-conditioning unit that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: **<Insert number>** year(s) from date of Substantial Completion.
 - 2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than **[five][10]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and Startup."
- D. ASHRAE 15 Compliance: For refrigeration system safety.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. UL Compliance: Comply with UL 1995.



- G. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.
 - 1. Design RTU supports to comply with **[wind][and][seismic]** performance requirements.
- H. Wind-Restraint Performance:
 - 1. RTUs, accessories, and components are to withstand the effects of wind. See Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for building classification criteria.
- I. Seismic Performance: RTUs, accessories, and components are to withstand the effects of earthquake motions. See Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified"**[and the unit will be fully operational after the seismic event]**.
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Supply-Air Fan:
 - 1. Fan Type: **[Belt drive][Direct drive]**, **[double width][single width]**, **[forward curved][backward inclined]**, centrifugal[, plenum].
 - 2. Airflow: **<Insert cfm (L/s)>**.
 - 3. External Static Pressure: **<Insert inches wg (kPa)>**.
 - 4. Fan Speed: **[Variable]<Insert rpm>**.
 - 5. Motor Characteristics:
 - a. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Open, externally ventilated][Totally enclosed, nonventilated][Severe duty][Explosion proof][Dust-ignition-proof machine]**.
 - b. Enclosure Materials: **[Cast iron][Cast aluminum][Rolled steel]**.
 - c. Horsepower: **<Insert horsepower>**.
 - d. Motor Speed: **[Multispeed][ECM][Constant]<Insert rpm>**.
 - e. Volts: **[115][208][230][460]<Insert value> V**.
 - f. Phase: **[Single][Three]**.
 - g. Hertz: 60.
 - h. Full-Load Amperes: **<Insert value> A**.
 - i. Minimum Circuit Ampacity: **<Insert value> A**.
 - j. Maximum Overcurrent Protection: **<Insert value> A**.
- B. Return/Relief-Air Fan:
 - 1. Fan Type: **[Belt drive][Direct drive]**, **[double width][single width]**, **[forward curved][backward inclined]**, centrifugal[, plenum].
 - 2. Airflow: **<Insert cfm (L/s)>**.
 - 3. External Static Pressure: **<Insert inches wg (kPa)>**.

4. Fan Speed: **<Insert rpm>**.
5. Motor Characteristics:
 - a. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Open, externally ventilated][Totally enclosed, nonventilated][Severe duty][Explosion proof][Dust-ignition-proof machine]**.
 - b. Enclosure Materials: **[Cast iron][Cast aluminum][Rolled steel]**.
 - c. Horsepower: **<Insert horsepower>**.
 - d. Motor Speed: **<Insert rpm>**.
 - e. Volts: **[115][208][230][460]<Insert value> V**.
 - f. Phase: **[Single][Three]**.
 - g. Hertz: 60.
 - h. Full-Load Amperes: **<Insert value> A**.
 - i. Minimum Circuit Ampacity: **<Insert value> A**.
 - j. Maximum Overcurrent Protection: **<Insert value> A**.

C. Outdoor-Air-Refrigerant Coil Fan:

1. Fan Type: **[Direct-drive propeller][Belt drive][Direct drive], [double width][single width], [forward curved][backward inclined], centrifugal, [scroll][plenum] fan**.
2. Airflow: **<Insert cfm (L/s)>**.
3. Static Pressure: **<Insert inches wg (kPa)>**.
4. Fan Speed: **<Insert rpm>**.
5. Motor Characteristics:
 - a. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Open, externally ventilated][Totally enclosed, nonventilated][Severe duty][Explosion proof][Dust-ignition-proof machine]**.
 - b. Enclosure Materials: **[Cast iron][Cast aluminum][Rolled steel]**.
 - c. Horsepower: **<Insert horsepower>**.
 - d. Motor Speed: **[Multispeed][ECM][Constant]<Insert rpm>**.
 - e. Volts: **[115][208][230][460]<Insert value> V**.
 - f. Phase: **[Single][Three]**.
 - g. Hertz: 60.
 - h. Full-Load Amperes: **<Insert value> A**.
 - i. Minimum Circuit Ampacity: **<Insert value> A**.
 - j. Maximum Overcurrent Protection: **<Insert value> A**.

D. Rotary Heat Exchanger:

1. Effectiveness: **<Insert percentage>**.
2. Intake:
 - a. Intake Airflow: **<Insert cfm (L/s)>**.
 - b. Pressure Differential: **<Insert inches wg (kPa)>**.
 - c. Entering Supply-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - d. Entering Supply-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - e. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - f. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
3. Exhaust:
 - a. Exhaust Airflow: **<Insert cfm (L/s)>**.
 - b. Entering Exhaust-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - c. Entering Exhaust-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - d. Leaving Exhaust-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.

e. Leaving Exhaust-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.

E. Supply-Air Refrigerant Coil:

1. Total Cooling Capacity: **<Insert Btu/h (kW)>**.
2. Sensible Cooling Capacity: **<Insert Btu/h (kW)>**.
3. Entering-Air Cooling Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
4. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
5. Refrigerant Type: **<Insert refrigerant type>**.
6. Total Heating Capacity: **<Insert Btu/h (kW)>**.
7. Entering-Air Heating Dry-Bulb Temperature: **<Insert deg F (deg C)>**.

F. Hot-Water Coil:

1. Coil Face Dimensions:
 - a. Finned Length: **<Insert inches (mm)>**.
 - b. Finned Width: **<Insert inches (mm)>**.
2. Minimum Fin Spacing: **[0.125 inch (3.18 mm)][0.091 inch (2.31 mm)][0.071 inch (1.81 mm)][0.067 inch (1.70 mm)][0.056 inch (1.41 mm)][0.0075 inch (0.19 mm)]<Insert dimension>**.
3. Tube Diameter: **[0.375 inch (9.5 mm)][0.50 inch (12.7 mm)][0.625 inch (15.9 mm)][0.75 inch (19.0 mm)][1.0 inch (25.4 mm)]<Insert dimension>**.
4. Number of Rows: **<Insert number>**.
5. Serpentine: **[Single][Half][Full]**.
6. Mounting: **[Slip in][Flanged]**.
7. Air Side:
 - a. Flow Rate: **<Insert cfm (L/s)>**.
 - b. Finned Area Face Velocity: **<Insert fpm (m/s)>**.
 - c. Static Pressure Drop: **<Insert inches wg (Pa)>**.
 - d. Total Capacity: **<Insert Btu/h (kW)>**.
 - e. Entering Temperature: **<Insert deg F (deg C)>**.
 - f. Leaving Temperature: **<Insert deg F (deg C)>**.
8. Water Side:
 - a. Flow Rate: **<Insert gpm (L/s)>**.
 - b. Tube Velocity: **<Insert fpm (m/s)>**.
 - c. Glycol Type: **[Ethylene][Propylene]**.
 - d. Aqueous Glycol Solution Concentration: **<Insert percentage>**.
 - e. Pressure Drop: **<Insert feet (kPa)>**.
 - f. Entering Temperature: **<Insert deg F (deg C)>**.
 - g. Leaving Temperature: **<Insert deg F (deg C)>**.

G. Steam Heating Coil:

1. Minimum Fin Spacing: **[0.125 inch (3.18 mm)][0.091 inch (2.31 mm)][0.071 inch (1.81 mm)][0.067 inch (1.70 mm)][0.056 inch (1.41 mm)][0.0075 inch (0.19 mm)]<Insert dimension>**.
2. Tube Diameter: **[0.50 inch (12.7 mm)][0.625 inch (15.9 mm)][0.75 inch (19.0 mm)]<Insert dimension>**.
3. Number of Rows: **[One][Two]<Insert number>**.

- 4. Air Side:
 - a. Finned Area Face Velocity: **<Insert fpm (m/s)>**.
 - b. Total Capacity: **<Insert Btu/h (kW)>**.
 - c. Entering Temperature: **<Insert deg F (deg C)>**.
 - d. Leaving Temperature: **<Insert deg F (deg C)>**.
- 5. Steam Side:
 - a. Inlet Pressure: **<Insert psig (kPa)>**.
 - b. Tube Type: **[Single][Distributing]**.
 - c. Condensing Capacity: **<Insert lb/h (g/s)>**.
 - d. Pressure Drop: **<Insert psig (kPa)>**.
- H. Outdoor-Air Refrigerant Coil:
 - 1. Ambient-Air Temperature: **<Insert deg F (deg C)>**.
 - 2. Coating: **[Baked phenolic][Cathodic epoxy]**.
 - 3. Fan Motor: **<Insert value>**.
 - 4. Number of Fans: **<Insert number>**.
 - 5. Refrigerant Type: **<Insert refrigerant type>**.
- I. Hot-Gas Reheat Coil:
 - 1. Heating Capacity: **<Insert Btu/h (kW)>**.
 - 2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - 3. Air-Temperature Rise: **<Insert deg F (deg C)>**.
 - 4. Refrigerant Type: **<Insert refrigerant type>**.
- J. Electric-Resistance Heating Coil:
 - 1. Capacity: **<Insert kilowatts>**.
 - 2. Number of Steps: **<Insert number>**.
- K. Compressors:
 - 1. Number of Refrigerant Circuits: **[One][Two]<Insert number>**.
 - 2. Compressor Speed: **[Single][Variable]**.
 - 3. Suction Temperature: **<Insert deg F (deg C)>**.
 - 4. Power Input: **<Insert kilowatts>**.
 - 5. Seasonal Energy Efficiency Ratio (SEER): **<Insert value>**.
- L. Gas Furnace:
 - 1. Airflow: **<Insert cfm (L/s)>**.
 - 2. Gas Control Valve: **[Single stage][Two stage][Modulating]**.
 - 3. Minimum AFUE: **<Insert number>** percent.
 - 4. Minimum Thermal Efficiency: **<Insert number>** percent.
 - 5. Minimum Combustion Efficiency: **<Insert number>** percent.
 - 6. Input: **<Insert Btu/h (kW)>**.
 - 7. Output: **<Insert Btu/h (kW)>**.
 - 8. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - 9. Air-Temperature Rise: **<Insert deg F (deg C)>**.
- M. Dampers:

1. Outdoor-Air Damper: Linked galvanized-steel damper blades mechanically fastened to galvanized-steel axels and operating rod, for zero to [25][30]<Insert number> percent outdoor air[, with electric motorized damper operator][, 115 V][, 24 V].
2. Outdoor- and Return-Air Mixing Dampers: [Parallel-][Opposed-]blade galvanized-steel dampers mechanically fastened to galvanized-steel axels and operating rod in reinforced cabinet. Connect operating rods with common linkage[or gears] and interconnect so dampers operate simultaneously. [Include 24 V motorized damper operators.][Include 115 V motorized damper operators.]
3. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IES 90.1.

N. Recirculating-Air Filters:

1. Type: <Insert type>.
2. Face Dimensions, Each: <Insert inches by inches (mm by mm)>.
3. Depth: <Insert inches (mm)>.
4. Number of Filters in Filter Bank: <Insert number> wide by <Insert number> high.
5. Access Location: [Side]<Insert location>.
6. Maximum or Rated Face Velocity: <Insert fpm (m/s)>.
7. Initial Resistance: <Insert inches wg (Pa)>.
8. Recommended Final Resistance: <Insert inches wg (Pa)>.
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating and Corresponding Average Arrestance: [MERV 4]<Insert MERV rating>, and corresponding average arrestance in accordance with ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: [MERV 6][MERV 13][MERV 13A]<Insert value>, in accordance with ASHRAE 52.2.

O. Outdoor-Air Filters:

1. Type: <Insert type>.
2. Face Dimensions, Each: <Insert inches by inches (mm by mm)>.
3. Depth: <Insert inches (mm)>.
4. Number of Filters in Filter Bank: <Insert number> wide by <Insert number> high.
5. Access Location: [Side]<Insert location>.
6. Maximum or Rated Face Velocity: <Insert fpm (m/s)>.
7. Initial Resistance: <Insert inches wg (Pa)>.
8. Recommended Final Resistance: <Insert inches wg (Pa)>.
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating and Corresponding Average Arrestance: [MERV 4]<Insert MERV rating>, and corresponding average arrestance in accordance with ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: [MERV 6][MERV 13][MERV 13A]<Insert value>, in accordance with ASHRAE 52.2.

P. Vibration Isolation and Seismic-Control Devices: <Insert device type>, with <Insert value> minimum deflection.

Q. Electrical Characteristics for Single-Point Connection:

1. Voltage: [115][208][230][460]<Insert value> V.
2. Phase: [Single][Three].
3. Hertz: [60]<Insert value>.
4. Full-Load Amperes: <Insert value> A.
5. Minimum Circuit Ampacity: <Insert value> A.
6. Maximum Overcurrent Protection: <Insert value> A.

R. Attenuator Insertion Loss Rating (ILR):

1. 1st Octave: <Insert value> dB.
2. 2nd Octave: <Insert value> dB.
3. 3rd Octave: <Insert value> dB.
4. 4th Octave: <Insert value> dB.
5. 5th Octave: <Insert value> dB.
6. 6th Octave: <Insert value> dB.
7. 7th Octave: <Insert value> dB.
8. 8th Octave: <Insert value> dB.

2.3 PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. [AAON]
2. [Addison]
3. [Allied Commercial]
4. [Daikin Applied]
5. [Duplicate Carrier Global Corporation]
6. [Engineered Air]
7. [Lennox]
8. [Rheem Manufacturing Company; Heating and Cooling Products]
9. [Trane]
10. [WaterFurnace International, Inc.]
11. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
12. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [AAON]
2. [Addison]
3. [Allied Commercial]
4. [Daikin Applied]
5. [Duplicate Carrier Global Corporation]
6. [Engineered Air]
7. [Lennox]
8. [Rheem Manufacturing Company; Heating and Cooling Products]
9. [Trane]
10. [WaterFurnace International, Inc.]
11. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
12. <Insert manufacturer's name>

C. Source Limitations: Obtain packaged, large-capacity, rooftop air-conditioning units from single manufacturer.

D. Unit Casings:

1. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
2. Double-Wall Construction:
 - a. Outside Casing Wall: **[ASTM A653/A653M galvanized steel]<Insert material>**, minimum **[18 gauges (1.3 mm)]<Insert value>** thick with **[manufacturer's standard finish][corrosion-resistant coating]<Insert special coating>**, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
 - b. Inside Casing Wall: **G90 (Z275)** coated, ASTM A653/A653M galvanized steel, **[0.034 inch (0.86 mm)][0.028 inch (0.7 mm)]<Insert dimension>** thick[, **perforated 40 percent free area**].
 - c. Floor Plate: **[G90 (Z275), ASTM A653/A653M galvanized steel]<Insert material>**, **[treadplate,]** minimum **[18 gauges (1.3 mm)]<Insert value>** thick.
 - d. Casing Insulation:
 - 1) Materials: **[Injected polyurethane foam][fiberglass]** insulation.
 - 2) Casing Panel R-Value: Minimum **<Insert value>**.
 - 3) Insulation Thickness: **[1 inch (25 mm)][2 inches (50 mm)]**.
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
3. Airstream Surfaces: Surfaces in contact with airstream to comply with requirements in ASHRAE 62.1.
4. Static-Pressure Classifications:
 - a. For Unit Sections Upstream of Fans: Minus **[2-inch wg (500 Pa)][3-inch wg (750 Pa)]<Insert value>**.
 - b. For Unit Sections Downstream and Including Fans: **[2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert value>**.
5. Panels and Doors:
 - a. Access Panels:
 - 1) Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - 2) Fasteners: Two or more camlock types for panel lift-out operation. Arrangement to allow panels to be opened against air-pressure differential.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow inspection and maintenance of air-handling unit's internal components. Dimensions to be at least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** wide by full height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>**.
 - b. Doors:
 - 1) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinges and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
 - 2) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 3) Size: Large enough to allow inspection and maintenance of air-handling unit's

internal components.

- c. Locations and Applications: Provide access doors to all locations indicated below unless limited dimensions of location make access door impractical. If door is impractical, provide panel.
 - 1) Fan Section: **[Inspection and access panels][and][doors]**.
 - 2) Access Section: Doors.
 - 3) Coil Section: Inspection and access panels.
 - 4) Damper Section: **[Inspection and access panels][Doors]**.
 - 5) Filter Section: **[Inspection and access panels][and][doors]**. Provide access door or panel large enough to allow periodic removal and installation of filters.
 - 6) Mixing Section: Doors.
 - d. Service Light: 100 W vaporproof fixture with switched junction box located **[outside][inside]** adjacent to door.
 - 1) Locations: **[Each section accessed with door][Fan section]<Insert location>**.
6. Condensate Drain Pans:
- a. Location: Each type of **[cooling coil][rotary heat exchanger]**.
 - b. Construction:
 - 1) Single-wall, **[ASTM A653/A653M galvanized-steel or noncorrosive polymer][stainless steel]** sheet.
 - 2) Double-wall, **[ASTM A653/A653M galvanized-steel or noncorrosive polymer][ASTM A240/A240M stainless steel]** sheet with space between walls filled with foam insulation and moisture-tight seal.
 - c. Drain Connection:
 - 1) Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **[one end][both ends]** of pan.
 - 2) Minimum Connection Size: **[NPS 1 (DN 25)][NPS 2 (DN 50)]<Insert pipe size>**.
 - d. Slope: Minimum **[0.125-in./ft. (10-mm/mm)]<Insert value>** slope, **to comply with ASHRAE 62.1,** in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
 - e. Length: Extend drain pan downstream from leaving face **[for distance to comply with ASHRAE 62.1]<Insert distance>**.
 - f. Width: Entire width of water producing device.
 - g. Depth: A minimum of **[2 inches (50 mm)]<Insert dimension>** deep.
 - h. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
 - i. Units with stacked coils are to have an intermediate drain pan to collect condensate from top coil, with piped drain to lower pan to prevent splashing.
- E. Fans, Drives, and Motors:
1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
 2. Supply-Air Fans: Centrifugal, rated in accordance with AMCA 210/ASHRAE 51; galvanized or painted steel; mounted on solid-steel shaft.

- a. Shafts: With field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway.
 - b. Shaft Bearings:
 - 1) Heavy-duty, self-aligning, pillow-block type with an **[L-50]<Insert bearing life rating>** rated life of minimum **[100,000]<Insert number>** hours in accordance with ABMA 9.
 - c. Housings, Scroll Fans: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - d. Bracing: Steel angle or channel supports for mounting and supporting **[fan scroll,]** wheel, motor, and accessories.
 - e. Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
 - f. Mounting: For internal vibration isolation **[and seismic control]**. Factory-mount fans with manufacturer's standard **[restrained]** vibration isolation mounting devices having a minimum static deflection of **[1 inch (25 mm)]<Insert dimension>**.
 - g. Shaft Lubrication Lines: Extended to a location outside the casing.
 - h. Flexible Connector: Factory fabricated with a fabric strip minimum **3-1/2 inches (89 mm)** wide, attached to two strips of minimum **2-3/4-inch- (70-mm-)** wide by **0.028-inch- (0.7-mm-)** thick, **[galvanized-steel][aluminum]** sheet.
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives are to comply with UL 181, Class 1.
3. Drives, Direct: Factory-mounted, direct drive.
 4. Drives, Belt: Factory-mounted, V-belt drive; with adjustable alignment and belt tensioning and with **[1.5][1.25]** service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards"; **[0.146-inch- (2.7-mm-)]<Insert dimension>** thick, **[3/4-inch (20-mm)]<Insert dimension>** diamond-mesh wire screen, welded to steel angle frame; prime coated.
 5. Outdoor-Air-Refrigerant-Coil Fan: Propeller fan mounted on shaft of permanently lubricated **[two-speed][three-speed][ECM]** motors.
 6. Relief-Air Fan: **[Propeller][Forward curved][Backward inclined]**, shaft mounted on permanently lubricated motor.
 7. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 - d. Enclosure Materials: **[Cast iron]<Insert material>**.
 - e. Motor Bearings: **<Insert requirements>**.
 - f. Unusual Service Conditions:

- 1) Ambient Temperature: **<Insert deg C>**.
 - 2) Altitude: **<Insert feet (m)>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
- g. Efficiency: Premium efficient as defined in NEMA MG 1.
- h. NEMA Design: **<Insert designation>**.
- i. Motor Pulleys: Adjustable pitch for use with **[5]<Insert number>**-hp motors and smaller; fixed pitch for use with motors larger than **[5]<Insert number>** hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
- j. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

F. Rotary Heat Exchangers:

1. Casing:
 - a. Galvanized steel, stainless steel, or aluminum with manufacturer's standard factory finish.
 - b. Integral purge section limiting carryover of exhaust air to between **[0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.5 percent at 400 Pa and 0.20 percent at 1000 Pa)]<Insert values>** differential pressure.
 - c. Casing seals on periphery of rotor, on duct divider, and on purge section.
 - d. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings. Support horizontal rotors on tapered roller bearing.
2. Rotor - Aluminum or Polymer: Segmented wheel, strengthened with radial spokes[, **with nontoxic, noncorrosive, silica-gel desiccant coating**].
3. Rotor - Aluminum, Metallic, or Polymer: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating.
4. Drive: Fractional horsepower motor and gear reducer[, **with speed changed by variable-frequency controller**]. Permanently lubricated wheel bearings with an **[L-10]<Insert bearing life>[400,000 hours]<Insert hours>**.
5. Controls:
 - a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
 - b. Variable-frequency controller, factory mounted and wired, permitting input of field-connected 4- to 20 mA or 1- to 10 V control signal.
 - c. Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
 - d. Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain[**exhaust temperature above freezing and**] air differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
 - e. Control energy recovery to permit air economizer operation.
 - 1) Bypass dampers to assist energy recovery control.
 - f. Pilot-Light Indicator: Display rotor rotation and speed.
 - g. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
 - h. Defrost cycle.
 - i. Integral purge section limiting carryover of exhaust air to between **[0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400 Pa and 0.20 percent at 1000 Pa)]<Insert value>** differential pressure.

G. Coils:

1. General Requirements for Coils:
 - a. Comply with AHRI 410.
 - b. Fabricate coils section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
 - c. Coils are to not act as structural component of unit.
2. Supply-Air Refrigerant Coil:
 - a. Tubes: **[Copper]<Insert material>**.
 - b. Fins:
 - 1) Fin Spacing: Maximum **[8][10][12]<Insert spacing>** fins per inch (mm).
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
 - e. Frames: **[Galvanized steel][Stainless steel]<Insert material frame>**.
 - f. Coatings: **[None][Corrosion-resistant coating]**.
 - g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum **300 psig (2070 kPa)**.
3. Supply-Air Hydronic Heating Coil:
 - a. Hot-Water Coils: **[Continuous circuit][Self-draining][Cleaning]**.
 - 1) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 2) Tube Material: **[Copper]<Insert material>**.
 - 3) Fin Type: Plate.
 - 4) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 5) Fin Thickness: **<Insert inches (mm)>**.
 - 6) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 7) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 8) Frames: Channel frame, minimum **0.052-inch- (1.3-mm-)** thick galvanized steel.
 - 9) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
 - 10) Coating: **[None][Corrosion-resistant coating]**.
 4. Steam Heating Coil:
 - a. Steam Coils: **[Distributed][Single tube]**.
 - 1) Steam Outer-Tube Diameter: **<Insert inches (mm)>**.

- 2) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 3) Tube Material: **[Copper]<Insert material>**.
 - 4) Fin Type: Plate.
 - 5) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 6) Fin Thickness: **<Insert inches (mm)>**.
 - 7) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 8) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 9) Frames: Channel frame, minimum **0.052-inch- (1.3-mm-)** thick galvanized steel.
 - 10) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
 - 11) Coating: **[None][Corrosion-resistant coating]**.
5. Outdoor-Air Refrigerant Coil:
- a. Tubes: **[Copper]<Insert material>**.
 - b. Fins:
 - 1) Material: **[Aluminum][Copper]<Insert material>**.
 - 2) Fin Spacing: Maximum **[8][10][12]<Insert spacing>** fins per **inch (mm)**.
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
 - e. Frames: **[Galvanized steel][Stainless steel]<Insert material frame>**.
 - f. Coatings: **[None][Corrosion-resistant coating]**.
 - g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum **300 psig (2070 kPa)**.
6. Hot-Gas Reheat Refrigerant Coil:
- a. Tubes: **[Copper]<Insert material>**.
 - b. Fins:
 - 1) Material: **[Aluminum][Copper]<Insert material>**.
 - 2) Fin Spacing: Maximum **[8][10][12]<Insert spacing>** fins per **inch (mm)**.
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
 - e. Frames: **[Galvanized steel][Stainless steel]<Insert material frame>**.
 - f. Coatings: **[None][Corrosion-resistant coating]**.
 - g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum **300 psig (2070 kPa)**.
 - h. Suction-discharge bypass valve.
7. Electric-Resistance Heating Coils: Comply with UL 1995.

- a. Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
- b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
- c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
- d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
- e. Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - 1) **[Magnetic][Mercury]** contactor.
 - 2) Solid-state, stepless pulse controller.
 - 3) Toggle switches, one per step.
 - 4) Step controller.
 - 5) Time-delay relay.
 - 6) Pilot lights, one per step.
 - 7) Airflow proving switch.

H. Refrigerant Circuit Components:

1. Number of Refrigerant Circuits: **[One][Two]<Insert number>**.
2. Compressor: Hermetic, **[variable speed]** scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, **and crankcase heater**.
3. Refrigeration Specialties:
 - a. Refrigerant: **[R-454B]<Insert refrigerant type>**.
 - b. Expansion valve with replaceable thermostatic element.
 - c. Refrigerant filter/dryer.
 - d. Manual-reset high-pressure safety switch.
 - e. Automatic-reset low-pressure safety switch.
 - f. Minimum off-time relay.
 - g. Automatic-reset compressor motor thermal overload.
 - h. Brass service valves installed in compressor suction and liquid lines.
 - i. Low-ambient kit high-pressure sensor.
 - j. Hot-gas reheat solenoid valve **[single stage][modulating]** with a replaceable magnetic coil.
 - k. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
 - l. Four-way reversing solenoid valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.
 - 1) Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 - 2) Seat: PTFE.
 - 3) End Connections: Threaded.
 - 4) Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with **1/2-inch (16-mm)** conduit adaptor, and **[24][115][208]** Vac coil.
 - 5) Working Pressure Rating: **[400 psig (2760 kPa)]<Insert pressure>**.
 - 6) Maximum Operating Temperature: **[240 deg F (116 deg C)]<Insert temperature>**.

I. Air Filtration:

1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
2. Panel Filters:

- a. Description: **[Flat, non-pleated][Pleated]**, factory-fabricated, self-supported, disposable air filters with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
 - d. Filter-Media Frame: **[Beverage board]<Insert material>** with perforated metal retainer, or metal grid, on outlet side.
3. Bag Filter:
- a. Description: Factory-fabricated, dry, extended-surface, self-supporting filters with holding frames in steel, basket-type retainers.
 - b. Filter Unit Class: UL 900.
 - c. Media: Fibrous material, with antimicrobial coating, constructed so individual pockets are maintained in tapered form by flexible internal supports under rated-airflow conditions.
 - d. Filter-Media Frame: **[Galvanized steel]<Insert material>**.
4. Cartridge Filters:
- a. Description: Factory-fabricated, **[adhesive-coated]** disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Fibrous material, with antimicrobial coating, constructed so individual pleats are maintained in pleated form under rated-airflow conditions by corrugated aluminum separators.
 - d. Filter Media Frame: **[Galvanized steel]<Insert material>**.
 - e. Adhesive: As recommended by adhesive manufacturer and with a VOC content of 80 g/L or less.

J. Gas Furnaces:

- 1. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.
- 2. CSA Approval: Designed and certified by and bearing label of CSA.
- 3. Burners: Stainless steel.
 - a. Rated Minimum Turndown Ratio: **[30 to 1]<Insert ratio>**.
 - b. Fuel: **[Natural][Propane]** gas.
 - c. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
 - d. Gas Control Valve: **[Single stage][Two stage][Modulating]**.
 - e. Gas Train: Single-body, regulated, redundant, 24 V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.
 - f. High-Altitude Model Kit: For Project elevations more than **2000 ft. (610 m)** above sea level.
- 4. Heat-Exchanger and Drain Pan: Stainless steel.
- 5. Venting, Gravity: Gravity vented **[with vertical extension]**.
- 6. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve **[with vertical extension]**.
- 7. Safety Controls:
 - a. Gas Manifold: Safety switches and controls complying with ANSI standards **[and][FM Global]<Insert insurer>**.

K. Antimicrobial UV Lamp System:

- 1. Description:

- a. UV-C lamp system consisting of power supply, power supply housing, wiring, UV lamp(s), lamp plug, lamp plug protector, encapsulated lamp, and lamp holder used for UV germicidal irradiation of cooling coil and condensate drain pan.
 - b. Factory installed and preengineered.
2. Standard: UL Category Control Number ABQK, HVAC accessories, air-duct mounted.
3. Lamps: High output, hot cathode.
4. Lamp-Holder Construction:
 - a. UV- and moisture-resistant materials and designed to connect the lamp to the plug.
 - b. Adjustable positioning.
5. Lamp-Clamp Construction:
 - a. UV- and moisture-resistant materials, watertight connection.
 - b. Adjustable positioning.
6. Lamp Protection: Hermetically sealed to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.
7. Lamp Output: UV-C energy, primarily at the 254 nm wavelength with a 360-degree energy distribution.
8. Access Door Interlocks: Automatic disconnect on all access doors into UV-installed casing sections to shield servicing personnel from contact with light.
9. Power Supply: UL-listed, single-point electrical connection[**with service disconnect**].
10. Power Consumption: Maximum of [15 W/sq. ft. (161 W/sq. m)]<Insert value>.

L. Sound-Attenuator Section:

1. General Requirements:
 - a. Factory fabricated.
 - b. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50; ASTM E84.
 - c. Airstream Surfaces: Surfaces in contact with airstream to comply with ASHRAE 62.1.
2. Shape: [Rectangular, straight][Round, straight][Rectangular, elbow][Round, elbow].
3. Rectangular Silencer Outer Casing: [Galvanized steel]<Insert material>.
4. Round Silencer Outer Casing: [Galvanized steel]<Insert material>.
5. Inner Casing and Baffles: [Galvanized steel]<Insert material>.
6. Principal Sound-Absorbing Mechanism:
 - a. Dissipative Type:[Polymer film-lined] absorptive fill material.
 - 1) Fill Material: [Inert and vermin-proof fibrous material]<Insert material type>.
 - b. Joints: Lock formed and sealed, continuously welded or flanged.

M. Dampers:

1. Comply with requirements in Section 230923.12 "Control Dampers."
2. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, [galvanized-steel]<Insert material> dampers with compressible jamb seals and extruded-vinyl blade edge

seals in **[opposed][parallel]**-blade arrangement with **[zinc-plated]** steel operating rods rotating in **[sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel]<Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate must not exceed **[4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa)]<Insert requirement>** rated in accordance with AMCA 500-D.

3. Barometric relief dampers.
4. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
5. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator to have visual scale indicating percent of travel and 2 to 10 V dc, feedback signal.
 - c. Operator Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains are completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
 - e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
 - f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
 - g. Coupling: V-bolt and V-shaped, toothed cradle.
 - h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
 - j. Power Requirements (Two-Position Spring Return): **[24 V dc][115 V ac][230 V ac]**.
 - k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
 - l. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2 to 10 V dc position feedback signal.
 - m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.
 - n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.

N. Electrical Power Connections:

1. RTU is to have a single connection of power to unit with[**unit-mounted disconnect switch accessible from outside unit and**] control-circuit transformer with built-in overcurrent protection.

O. Controls:

1. Control equipment is specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Sequence of operation is specified [**in Section 230993.11 "Sequence of Operations for HVAC DDC."**][**on Drawings.**]
3. Unit Controls:
 - a. Control-voltage transformer.
 - b. Wall-mounted thermostat or sensor with the following features:
 - 1) Heat-cool-off switch.
 - 2) Fan on-auto switch.
 - 3) Fan-speed switch.
 - 4) [**Manual**][**Automatic**] changeover.
 - 5) Adjustable deadband.
 - 6) [**Concealed**][**Exposed**] set point.
 - 7) [**Concealed**][**Exposed**] indication.
 - 8) [**Degree F**][**Degree C**] indication for the following:
 - a) Space temperature.
 - b) Supply-air temperature.
 - c) Outdoor-air temperature.
 - d) Space set point.
 - 9) Unoccupied-period-override push button.
 - 10) Data entry and access port to input temperature[**and humidity**] set points, occupied and unoccupied periods, and output room temperature[**and humidity**], supply-air temperature, operating mode, and status.
 - c. Wall-mounted humidistat or sensor with the following features:
 - 1) [**Concealed**][**Exposed**] set point.
 - 2) [**Concealed**][**Exposed**] indication.
 - d. Annunciator Panel for Each Unit:
 - 1) Configuration: [**Remote wall-**][**Unit**] mounted.
 - 2) Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
 - 3) DDC controller or programmable timer and interface with HVAC instrumentation and control system.
 - 4) Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.
4. Controller: [**Electronic**][**DDC**].

- a. Controller is to have volatile-memory backup.
- b. Safety Control Operation:
 - 1) Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire-alarm control panel.
 - 2) Firestats: Stop fan and close outdoor-air damper if air greater than **[130 deg F (54 deg C)]<Insert temperature>** enters unit. Provide additional contacts for alarm interface to fire-alarm control panel.
 - 3) Fire-Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in **[Section 284600 "Fire Detection and Alarm"]****[and]****[Section 284614 "Single- and Multiple-Station Alarms."]**
 - 4) Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than **[40 deg F (4 deg C)]<Insert temperature>**.
 - 5) Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
- c. Scheduled Operation: Occupied and unoccupied periods on **[seven]****[365]**-day clock with a minimum of **[two]****[four]** programmable periods per day.
- d. Unoccupied Period:
 - 1) Heating Unoccupied: **[60 deg F (15.6 deg C)]<Insert unoccupied temperature>**.
 - 2) Cooling Unoccupied: **[78 deg F (25 deg C)]<Insert unoccupied temperature>****[System off]**.
 - 3) Override Operation: **[Two]****<Insert number>** hours.
- e. Supply Fan Operation:
 - 1) Occupied Periods: Run fan continuously.
 - 2) Unoccupied Periods: Cycle fan to maintain heating unoccupied temperature.
- f. Refrigerant Circuit Operation:
 - 1) Occupied Periods: Cycle or stage compressors**[, and operate hot-gas bypass]** to match compressor output to cooling load to maintain **[room]****[discharge]** temperature**[and humidity]**. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
 - 2) Unoccupied Periods: **[Compressors off]****[Cycle compressors and condenser fans to maintain heating unoccupied temperature]****[and]****[cycle compressors and condenser fans to maintain cooling unoccupied temperature]**.
 - 3) Switch reversing valve for heating or cooling mode on air-to-air heat pump.
- g. Hot-Gas Reheat-Coil Operation:
 - 1) Occupied Periods: Humidistat opens hot-gas valve to provide hot-gas reheat, and cycles compressor.
 - 2) Unoccupied Periods: Reheat is not required.
- h. Gas Furnace Operation:
 - 1) Occupied Periods: **[Cycle]****[Stage]****[Modulate]** burner to maintain **[room]****[discharge]** temperature.
 - 2) Unoccupied Periods: Cycle burner to maintain unoccupied heating temperature.
 - 3) Operate supplemental gas furnace for heating with outdoor temperature below **[plus 25 deg F (minus 4 deg C)]<Insert temperature>**.
- i. Electric-Heating-Coil Operation:

- 1) Occupied Periods: **[Cycle][Stage][Modulate]** coil to maintain **[room][discharge]** temperature.
 - 2) Unoccupied Periods: Energize coil to maintain unoccupied heating temperature.
 - 3) Operate supplemental electric heating coil with compressor for heating with outdoor temperature below **[plus 25 deg F (minus 4 deg C)]<Insert temperature>**.
- j. Fixed Minimum Outdoor-Air Damper Operation:
- 1) Occupied Periods: Open to **[25]<Insert number>** percent.
 - 2) Unoccupied Periods: Close the outdoor-air damper.
- k. Economizer Outdoor-Air Damper Operation:
- 1) Economizer Cycle: Controller is to permit outdoor air-side economizer operation when **[outdoor-air temperature][outdoor-air enthalpy]** is lower than **[return-air temperature][return-air enthalpy]**. When this condition is untrue, outdoor damper is not permitted to open beyond minimum intake airflow setting. When air-side economizer cycle is in operation, outdoor-air volume is to be modulated to maintain mixed-air temperature no lower than **[unit supply-air temperature set point]<Insert temperature>**. Minimum outdoor airflow is not to be reduced below **[10 percent][25 percent][1000 cfm (472 L/s)]<Insert value>**.
 - 2) Morning Warmup Cycle:
 - a) For outdoor-air temperature lower than return-air temperature, close outdoor-air damper and open return-air damper.
 - b) For outdoor-air temperature higher than return-air temperature, open outdoor-air damper and close return-air damper.
 - 3) Morning Cool-Down Cycle:
 - a) For outdoor-air **[temperature][enthalpy]** higher than return-air **[temperature][enthalpy]**, close outdoor-air damper and open return-air damper.
 - b) For outdoor-air **[temperature][enthalpy]** lower than return-air **[temperature][enthalpy]**, open outdoor-air damper and close return-air damper.
 - 4) Building Outdoor-Air Flush Cycle: Open outdoor-air damper and close return-air damper.
 - 5) Occupied Periods: Open to **[10][25]<Insert number>** percent fixed minimum intake, and maximum 100 percent of fan capacity. Controller is to permit air-side economizer operation when **[outdoor-air temperature is less than return-air temperature][outdoor-air enthalpy is less than return-air enthalpy][outdoor-air temperature is less than 60 deg F (15 deg C)]<Insert temperature>**. Controller modulates outdoor-air and return-air dampers to maintain a mixed-air temperature of **[55 deg F (13 deg C)]<Insert temperature>**.
 - 6) Relief-Air Fan: Start relief-air fan with end switch on outdoor-air damper.
 - 7) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
- l. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor to adjust for temperature, and output to range from **[2 to 10 V dc][4 to 20 mA]<Insert value>**.
- m. Carbon Dioxide Sensor Operation:

- 1) Occupied Periods: Reset minimum outdoor-air ratio down to minimum **[10]<Insert number>** percent to maintain maximum **[1000 ppm]<Insert value>** concentration.
 - 2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
- n. Terminal-Unit Relays: Provide heating- and cooling-mode changeover relays compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."
5. Interface Requirements for HVAC Instrumentation and Control System:
- a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
 - c. Provide **[BACnet][or][LonWorks]** compatible interface for central HVAC control workstation for the following:
 - 1) Adjusting set points.
 - 2) Monitoring supply fan start, stop, and operation.
 - 3) Inquiring data to include the following:
 - a) Outdoor-air temperature[**and humidity**].
 - b) Outdoor-air damper position.
 - c) Supply-air temperature.
 - d) Mixed-air temperature.
 - e) Room-air temperature[**and humidity**].
 - 4) Monitoring occupied and unoccupied operations.
 - 5) Monitoring constant and variable motor loads.
 - 6) Monitoring variable-frequency drive operation.
 - 7) Monitoring cooling load.
 - 8) Monitoring economizer cycles.
 - 9) Monitoring air-distribution static pressure and ventilation air volume.

P. Roof Curbs:

1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for wind-load requirements.
3. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 - a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1) Materials: ASTM C1071, Type I or II.
 - 2) Thickness: **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert thickness>**.
 - b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C916, Type I.
 - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when

- 3) applied as recommended by manufacturer and without causing leakage in cabinet. Liner materials applied in this location to have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
4. Curb Dimensions: Height of **[14 inches (355 mm)][24 inches (610 mm)][36 inches (910 mm)]<Insert height>.[Adaptable horizontal dimensions as required for existing roof openings.]**

Q. Accessories:

1. Electric heater with integral thermostat maintains minimum **50 deg F (10 deg C)** temperature in gas burner compartment.
2. Duplex, 115 V, ground-fault-interrupter outlet with 15 A overcurrent protection. Include transformer if required. **[Outlet is to be energized even if the unit main disconnect is open.]**
3. Low-ambient kit using **[staged][damper on][variable-speed]** condenser fans for operation down to **[35 deg F (1.7 deg C)]<Insert temperature>.**
4. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
5. Remote potentiometer to adjust minimum economizer damper position.
6. Return-air bypass damper.
7. Factory- or field-installed, demand-controlled ventilation.
8. Safeties:
 - a. Smoke detector.
 - b. Condensate overflow switch.
 - c. Phase-loss **[reversal]** protection.
 - d. High **[and low]** pressure control.
 - e. **[Gas furnace][Electric coil]** airflow-proving switch.
9. Coil guards of painted, galvanized-steel wire.
10. Hail guards of galvanized steel, painted to match casing.
11. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.
12. Vertical vent extensions to increase the separation between the outdoor-air intake and the flue-gas outlet.
13. Door switches to disable heating or reset set point when open.
14. Outdoor-air intake weather hood **[with moisture eliminator]**.
15. Service Lights and Switch: Factory installed in **[fan section][fan and coil sections][each accessible section]<Insert locations>** with weatherproof cover. Factory wire lights to a single-point field connection.

R. Corrosion-Resistant Coating:

1. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
2. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding **[3000]<Insert time>-hour salt-spray test in accordance with ASTM B117.**
 - a. Standards:
 - 1) ASTM B117 for salt spray.
 - 2) ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
 - 3) ASTM D3359 for cross-hatch adhesion of 5B.

- b. Application: **[Immersion][Spray]**.
- c. Thickness: **[1 mil (0.025 mm)]<Insert value>**.
- d. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.4 SOURCE QUALITY CONTROL

A. AHRI Compliance:

- 1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
- 2. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.
- 3. Comply with AHRI 270 for testing and rating sound performance for RTUs.
- 4. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA Certification:

- 1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance in accordance with AMCA 211 and AMCA 311.
- 2. Damper leakage tested in accordance with AMCA 500-D.
- 3. Operating Limits: Classify in accordance with AMCA 99.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Examine roofs for suitable conditions where RTUs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

- A. Roof Curb: Install on roof structure or concrete base, level and secure, in accordance with **[NRCA's "NRCA Roofing Manual: Membrane Roof Systems."][AHRI Guideline B.]** Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
 - 1. Install normal-weight, **3000 psi (20.7 MPa)**, compressive strength (28-day) concrete mix inside roof curb, **[4 inches (100 mm)]<Insert dimension>** thick. Concrete, formwork, and reinforcement are specified with concrete.
- B. Unit Support: Install unit level on structural **[curbs][steel supports]**. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.
- C. Equipment Mounting:



1. Install RTUs on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to RTU, allow space for service and maintenance.
- C. Connect piping to unit mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using [NPS 1-1/4 (DN 32)]<Insert pipe size>, **ASTM B88, Type M (ASTM B88M, Type C)** copper tubing. Extend to nearest equipment or roof drain. Construct deep trap [of indicated depth] at connection to drain pan and install cleanouts at changes in direction.
- E. Gas Piping: Comply with applicable requirements in [Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping."] Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- F. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- G. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.
- H. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 DUCT CONNECTIONS

- A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 1. Install ducts to termination at top of roof curb.
 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
 4. Install return-air duct continuously through roof structure.

3.5 ELECTRICAL CONNECTIONS

- A. Connect electrical wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate is to be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least **1/2 inch (13 mm)** high.
 - 3. Locate nameplate where easily visible.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.7 CLEANING

- A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.8 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Inspect for visible damage to unit casing.
 - 3. Inspect for visible damage to furnace combustion chamber.
 - 4. Inspect for visible damage to compressor, coils, and fans.
 - 5. Inspect internal insulation.
 - 6. Verify that labels are clearly visible.
 - 7. Verify that clearances have been provided for servicing.
 - 8. Verify that controls are connected and operable.
 - 9. Verify that filters are installed.
 - 10. Clean all coils and inspect for construction debris.
 - 11. Clean furnace flue and inspect for construction debris.
 - 12. Connect and purge gas line.
 - 13. Remove packing from vibration isolators.
 - 14. Inspect operation of barometric relief dampers.
 - 15. Verify lubrication on fan and motor bearings.
 - 16. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 17. Adjust fan belts to proper alignment and tension.
 - 18. Start unit in accordance with manufacturer's written instructions.

- a. Start refrigeration system.
 - b. Do not operate below recommended low-ambient temperature.
 - c. Complete startup sheets and attach copy with Contractor's startup report.
19. Inspect and record performance of interlocks and protective devices; verify sequences of operation.
20. Operate unit for an initial period as recommended or required by manufacturer.
21. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
 - a. Measure gas pressure on manifold.
 - b. Inspect operation of power vents.
 - c. Measure combustion-air temperature at inlet to combustion chamber.
 - d. Measure flue-gas temperature at furnace discharge.
 - e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
22. Calibrate thermostats.
23. Adjust and inspect high-temperature limits.
24. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
25. Start refrigeration system and measure and record the following when ambient is a minimum of **15 deg F (8 deg C)** above return-air temperature:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outdoor-air, dry-bulb temperature.
 - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
26. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
27. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Return-air volume.
 - c. Relief-air volume.
 - d. Outdoor-air intake volume.
28. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
29. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
 - a. High-temperature limit on gas-fired heat exchanger.
 - b. Low-temperature safety operation.
 - c. Filter high-pressure differential alarm.
 - d. Economizer to minimum outdoor-air changeover.
 - e. Relief-air fan operation.
 - f. Smoke and firestat alarms.

30. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.9 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. RTU will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.11 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 23 74 16 13



THIS PAGE INTENTIONALLY LEFT BLANK



SECTION 23 74 16 13A - SELF-CONTAINED AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Self-contained air-conditioners.

1.2 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for self-contained air-conditioners.
 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable design submittals.
- C. Shop Drawings:
1. Include plans, elevations, sections, and **[mounting][attachment]** details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 4. Include diagrams for power, signal, and control wiring.
- D. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Detail self-contained air-conditioners and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Structural members to which self-contained air-conditioners will be attached.

- B. Seismic Qualification Data: Certificates, for self-contained air-conditioners, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For self-contained air-conditioners to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: **[One]<Insert number>** set(s) of filters for each unit.
 - 2. Fan Belts: **[One]<Insert number>** set(s) of belts for each unit.
 - 3. Gaskets: **[One]<Insert number>** set(s) for each access door.
 - 4. Fuses: **[One]<Insert number>** set(s) for each air-handling unit.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Comply with self-contained air-conditioner manufacturer's written instructions for handling.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of self-contained air-conditioners that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period:
 - a. For Compressor: **[One][Five]<Insert number>** year(s) from date of Substantial Completion.
 - b. For Parts: **[One][Five]<Insert number>** year(s) from date of Substantial Completion.
 - c. For Labor: **[One][Five]<Insert number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 - 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.
- D. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- E. Seismic Performance: Self-contained air-conditioners shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**]**<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: [**1.5**][**1.0**].
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Cooling Capacity:
 - 1. Total: **<Insert number> Btu/h (kW)**.
 - 2. Sensible: **<Insert number> Btu/h (kW)**.
 - 3. Seasonal Energy-Efficiency Ratio: [**10.0**][**12.0**][**13.0**][**14.0**][**16.0**]**<Insert ratio>**.
 - 4. Energy-Efficiency Ratio: [**10.0**][**12.0**][**13.0**][**14.0**][**16.0**]**<Insert ratio>**.
 - 5. Entering-Air Temperature:
 - a. Dry Bulb: **<Insert number> deg F (deg C)**.
 - b. Wet Bulb: **<Insert number> deg F (deg C)**.
 - 6. Leaving-Air Temperature:
 - a. Dry Bulb: **<Insert number> deg F (deg C)**.
 - b. Wet Bulb: **<Insert number> deg F (deg C)**.
- B. Heating Capacity:
 - 1. Total: **<Insert number> Btu/h (kW)**.

2. Air-Temperature Rise: **<Insert number> deg F (deg C).**
3. Airflow:
 - a. High: **<Insert number> cfm (L/s).**
 - b. Low: **<Insert number> cfm (L/s).**
4. Hot Water:
 - a. Entering-Water Temperature: **<Insert number> deg F (deg C).**
 - b. Leaving-Water Temperature: **<Insert number> deg F (deg C).**
 - c. Water Flow: **<Insert number> gpm (L/s).**
 - d. Water Pressure Drop: **<Insert number> feet of head (kPa).**
5. Electric Heat:
 - a. Total Capacity: **<Insert number> Btu/h (kW).**
 - b. Air-Temperature Rise: **<Insert number> deg F (deg C).**
 - c. Control Steps: **[One][Two][Three]<Insert number>.**

C. Supply-Air Fan:

1. Size: **<Insert number> hp (W).**
2. Total Airflow:
 - a. High: **<Insert number> cfm (L/s).**
 - b. Low: **<Insert number> cfm (L/s).**
3. Outdoor Airflow: **<Insert number> cfm (L/s).**

D. Air-Cooled Condenser:

1. Number of Fans: **[Two][Four]<Insert number>.**
2. Motor Speed: **<Insert value> rpm.**
3. Motor Horsepower (Watts): **<Insert number> hp (W).**
4. Ambient Temperature: **<Insert number> deg F (deg C).**

E. Water-Cooled Condenser:

1. Entering-Water Temperature: **<Insert number> deg F (deg C).**
2. Leaving-Water Temperature: **<Insert number> deg F (deg C).**
3. Water Flow: **<Insert number> gpm (L/s).**
4. Water Pressure Drop: **<Insert number> feet of head (kW).**

F. Filters:

1. Type: **<Insert type>.**
2. Face Dimensions, each: **<Insert number> inches by inches (mm by mm).**
3. Depth: **<Insert number> inches (mm).**
4. Numbers of Filters, Wide by High: **<Insert number>.**
5. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s).**
6. Initial Resistance: **<Insert number> inches wg (Pa).**
7. Recommended Final Resistance: **<Insert number> inches wg (Pa).**
8. Minimum Efficiency Reporting Value and Average Arrestance:

- a. MERV Rating: **[MERV 4]<Insert value>**, and corresponding average arrestance according to ASHRAE 52.2.
- 9. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 13]<Insert value>**, according to ASHRAE 52.2.
- G. Accessories:
 - 1. Manual outdoor-air damper.
 - 2. Motorized outdoor-air damper.
 - 3. Air-side economizer.
 - 4. Water-side economizer.
 - 5. Hot-gas bypass.
 - 6. Air Pressure Switch: Indicates when differential pressure exceeds set point representing dirty filters.
- H. Single-Point Electrical Characteristics:
 - 1. Volts: **[120][208][230][460]<Insert number> V.**
 - 2. Phase: **[Single][Three].**
 - 3. Hertz: 60 Hz.
 - 4. Full-Load Amperes: **<Insert number> A.**
 - 5. Minimum Circuit Ampacity: **<Insert number> A.**
 - 6. Maximum Overcurrent Protection: **<Insert number> A.**

2.3 SELF-CONTAINED AIR-CONDITIONERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Bard Manufacturing Company]**
 - 2. **[Carrier Global Corporation]**
 - 3. **[Daikin Applied]**
 - 4. **[Engineered Air]**
 - 5. **[Rheem Manufacturing Company; Heating and Cooling Products]**
 - 6. **[Trane Inc.]**
 - 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Bard Manufacturing Company]**
 - 2. **[Carrier Global Corporation]**
 - 3. **[Daikin Applied]**
 - 4. **[Engineered Air]**
 - 5. **[Rheem Manufacturing Company; Heating and Cooling Products]**
 - 6. **[Trane Inc.]**
 - 7. **<Insert manufacturer's name>**
- C. Description: Factory assembled, wired, and tested; and fully charged with refrigerant and oil.
- D. Configuration:



1. Horizontal, ceiling[-plenum] mounted.
2. Vertical, floor mounted; [vertical][and][horizontal] discharge.
3. Horizontal, ceiling mounted and vertical, floor mounted; [vertical][and][horizontal] discharge.

E. Disconnect Switch: Factory mounted [in control panel][on cabinet].

2.4 CABINET

A. Frame and Panels: Structural-steel frame with galvanized-steel panels and access doors or panels.

1. Exterior-Surface Finish: Factory painted in color selected by Architect.
2. Interior-Surface Finish: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Insulation: [1-inch- (25-mm-) thick, glass-fiber duct liner complying with ASTM C1091 and having a microbial coating on cabinet interior and control panel.]<Insert insulation thickness and type>.

C. Return-Air Opening: Rear, [open][flange for duct connection].

D. Corrosion-Resistant Treatment: [None][Phenolic coating on unit interior and exterior]<Insert coating type and casing location>.

2.5 SUPPLY-AIR FAN

A. Fan Material: Galvanized steel.

B. Configuration: Double-width, double-inlet, [forward-curved][airfoil] centrifugal fan; statically and dynamically balanced. [Vertical][Horizontal] discharge with flexible discharge collar.

C. Drive: [Belt][, with permanently lubricated bearings][, with greaseable bearings][Direct, with fan and motor resiliently mounted].

D. Motor Type: [Multispeed, permanent split case][Open-dripproof][Totally enclosed fan-cooled][Electronically commutated variable speed]<Insert type> type.

E. Motor Sheave: [Fixed][Variable and adjustable] pitch, dynamically balanced, and selected to achieve specified rpm when set at midposition.

F. Fan Sheaves: [Variable][Fixed] pitch, dynamically balanced, bored to fit shafts, and keyed for initial startup.

G. Belt Rating: As recommended by manufacturer or a minimum of one and one-half times nameplate rating of motor.

H. Bearings: Grease lubricated with grease lines extended to exterior of unit[with L-50 life at 200,000 hours]<Insert life rating and hours>.

I. Variable-frequency motor controller complies with Section 262923 "Variable-Frequency Motor Controllers."

J. Variable-Frequency Motor Controller: Serving each fan.

1. Manufactured Units: Pulse-width modulated; **[constant torque][and][variable torque]<Insert application> for [Design A and Design B][inverter-duty] motors.**
2. Output Rating: Three phase; 10 to **[60 Hz, with voltage proportional to frequency throughout voltage range][66 Hz, with torque constant as speed changes]**; maximum voltage equals input voltage.
3. Unit Operating Requirements:
 - a. Internal Adjustability:
 - 1) Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2) Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3) Acceleration: **[0.1 to 999.9]<Insert range> seconds.**
 - 4) Deceleration: **[0.1 to 999.9]<Insert range> seconds.**
 - 5) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - b. Self-Protection and Reliability Features:
 - 1) Surge suppression.
 - 2) Loss of input signal protections.
 - 3) Under- and overvoltage trips.
 - 4) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - 5) Critical frequency rejection.
 - 6) Loss-of-phase protection.
 - 7) Reverse-phase protection.
 - 8) Motor-temperature fault.
 - c. Bidirectional autospeed search.
 - d. Torque boost.
 - e. Motor temperature compensation at slow speeds.
 - 1) Panel-mounted operator station.
 - 2) Historical logging information and displays.
 - 3) Digital indicating devices.
 - f. Control Signal Interface: Electric.
 - g. Proportional Integral Derivative control interface.
 - h. DDC system for HVAC Protocols for Network Communications: **[ASHRAE 135]<Insert protocol type>.**
4. Line Conditioning:
 - a. Input line conditioning.
 - b. Output filtering.
 - c. EMI/RFI filtering.
5. Bypass Systems:
 - a. Bypass Mode: **[Manual operation only][Field-selectable automatic or manual].**
 - b. Bypass Controller:
 - 1) Two-contactor style, with bypass and output isolating contactors **[and isolating switch].**
 - 2) Three-contactor style, with bypass and input and output isolating contactors **[and isolating switch].**
 - c. Bypass Contactor Configuration: **[Full-voltage (across the line)][Reduced-voltage**

(autotransformer)]<Insert type> type.

- K. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 1. Special Motor Features: Premium efficiency, as defined in Section 230500 "Common Work Results for HVAC."
 - 2. <Insert unique motor characteristics>.
- L. Isolation: Mount fan and motor on common subbase and mount assembly on spring isolators with minimum static deflection of [1 inch (25 mm)]<Insert deflection>.
- M. Outdoor-Air-Intake Accessories:
 - 1. Barometric Outdoor-Air Damper: Adjustable-blade damper allowing induction of up to 25 percent outdoor air when evaporator fan is running.
 - 2. Motorized Outdoor-Air Damper: Motorized, two-position blade damper allowing induction of up to 25 percent outdoor air; with spring-return, low-voltage damper motor.
 - 3. Energy-Recovery Ventilator: Assembly of desiccant-coated, heat-recovery wheels and centrifugal exhaust fans to transfer approximately [67]<Insert number> percent of the difference between the sensible and latent heat of outdoor and exhaust air; with <Insert type and depth> filter on outside-air inlet side to keep ventilator clean.
 - 4. Air-Side Economizer: Damper assembly allowing induction of up to 100 percent outdoor air to maintain a selected mixed-air temperature; and exhaust damper and spring-return, low-voltage, modulating damper motor with minimum position adjustment.

2.6 REFRIGERATION SYSTEM

- A. Compressor: Scroll type, hermetically sealed, 3600 rpm maximum, and resiliently mounted with positive lubrication and internal motor protection.
- B. Refrigerant Coils: [Indoor and outdoor for air-cooled units,]seamless copper tubes expanded into aluminum fins.
 - 1. Coating: [None][Corrosion resistant].
 - 2. Refrigerant Circuits: A separate circuit for each compressor, with externally equalized thermal-expansion valve[with adjustable superheat], filter dryer,[sight glass, high-pressure relief valve,] and charging valves.
 - 3. Mount coil assembly over sloped, stainless-steel drain pan[complying with ASHRAE 62.1][and][having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir].
 - 4. Refrigerant: [R-407C][or][R-410A].
 - 5. Refrigerant dryer.
 - 6. High-pressure switch.
 - 7. Low-pressure switch.
 - 8. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
 - 9. Low ambient temperature switch.
 - 10. Brass service valves installed in discharge and liquid lines.
- C. Water-Cooled Condenser:
 - 1. Description: Factory assembled and tested; tube-in-tube coaxial type with water-regulating valve.
 - 2. Tubing: [Nonferrous][Copper][Cupronickel][Steel] inner tube.
 - 3. Coating: [None][Corrosion resistant].

D. Water-Side Economizer Section:

1. Description: Factory assembled and tested; consisting of water coil, modulating valves, controls, piping with cleanouts, and access panels.
2. Water Coil: **[Two][Four]** rows, copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, and **[copper][cast-iron]** headers; having a two-position control valve.

2.7 HEATING COIL

- A. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**; having a two-position control valve.
- B. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow-proving device; and one-time fuses in terminal box for overcurrent protection.

2.8 CONTROLS

- A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- B. Control Package, Factory Wired: Including contactor, high- and low-pressure cutouts, internal-winding thermostat for compressor, control-circuit transformer, and noncycling reset relay.
 1. System Selector Switch: **[Heat-off-cool][Off-heat-auto-cool]**.
 2. Adjustable Thermostat: **[Unit mounted][Remote]** to control the following:
 - a. Supply fan.
 - b. Compressor.
 - c. Condenser.
 - d. Hot-water coil valve.
 - e. Electric heater.
 3. Time-Delay Relay: Delay in starting lag compressor to prevent power demand surges.
 4. Antirecycle Timer: Locks out the compressor for an interval of time to prevent rapid starting and stopping.
- C. Control Package, Microprocessor Control Panel: Controls unit functions as **[standalone][full BAS communication via BACnet MS/TP][full BAS communication via BACnet/IP][full BAS communication via LON][full BAS communication via MODBUS]**, including refrigeration and safety controls, with unit-mounted display, and the following:
 1. Supply fan.
 2. Supply-fan motor speed.
 3. Compressors.
 4. Air-cooled condenser.
 5. Cooling tower pump.
 6. Modulating, hot-water coil valve.
 7. Multistep, electric heater.
 8. Time-of-day control to cycle unit on and off.
 9. Night-heat, morning warm-up cycle.
 10. Economizer control.
 11. Panel-mounted control switch to operate unit in remote or local control mode or to stop or reset.

12. Panel-mounted indication of the following:
 - a. Operating status.
 - b. System diagnostics and safety alarms.
 - c. Supply-air temperature set point.
 - d. Zone heating-temperature set point.
 - e. Supply-air pressure set point.
 - f. Economizer minimum position set point.
 - g. Supply-air-pressure, high-limit set point.

2.9 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a [3000]<Insert time>-hour salt-spray test according to ASTM B117.

1. Standards:

- a. ASTM B117 for salt spray.
- b. ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
- c. ASTM B3359 for cross-hatch adhesion of 5B.

2. Application: [Immersion][Spray].

3. Thickness: [1 mil (0.025 mm)]<Insert value>.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.10 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. AHRI 210/240 Certification: Units and their components shall be factory tested according to AHRI 210/240 and shall be listed and labeled by AHRI.
2. AHRI 340/360 Certification: Units and their components shall be factory tested according to AHRI 340/360 and shall be listed and labeled by AHRI.
3. AHRI 390 Certification: Units and their components shall be factory tested according to AHRI 390 and shall be listed and labeled by AHRI.

- B. ETL listed.
- C. Water Coils: Factory tested to minimum **300-psig (2070-kPa)** internal pressure while underwater according to AHRI 410 and ASHRAE 33.
- D. Refrigerant Coils: Factory tested to minimum **450-psig (3100-kPa)** internal pressure and to minimum **300-psig (2070-kPa)** internal pressure while underwater, according to AHRI 410 and ASHRAE 33.
- E. Water-Cooled Condenser: Refrigerant and water side factory tested to minimum **400-psig (2760 kPa)** internal pressure while underwater.
- F. Water-Side Economizer: Factory tested to minimum **300-psig (2070-kPa)** internal pressure while underwater.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Equipment Mounting:
 - 1. Install air-handling units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."
 - 3. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 4. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Suspended Units: Suspend[**and brace**] units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in [**Section 230548 "Vibration and Seismic Controls for HVAC."**][**Section 230548.13 "Vibration Controls for HVAC."**]
- C. Arrange installation of units to provide access space around units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
- E. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- F. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply[**and return**] ducts to self-contained air-conditioners with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.2 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.



- B. Connect condensate drain pans using [NPS 1-1/4 (DN 32)]<Insert pipe size>, ASTM B88, Type M (ASTM B88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- C. Hot-Water Coil Connections: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection, and with throttling-duty valve and union or flange on the return connection.
- D. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.
- E. Water-Cooled Condenser Connections: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Connect to supply and return with shutoff-duty valve and union or flange on the supply connection, and with throttling-duty valve and union or flange on the return connection.
- F. Where installing piping adjacent to equipment, allow space for service and maintenance.
- G. Connect piping to units mounted on vibration isolators with flexible connectors.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.